

A COMPARATIVE ANALYSIS FOR IMPROVING PUBLIC
TRANSPORTATION TO SATELLITE AREAS

A THESIS

Presented to

The Faculty of the Division of
Graduate Studies

By

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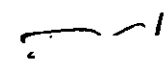
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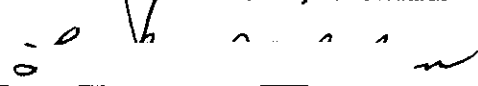
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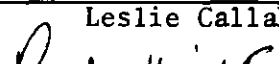
Approved:



Paul Jones, Chairman



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Paul Wright

Date approved by Chairman: 5-23-75

To My Mother
and
Father

ACKNOWLEDGMENTS

It is my privilege to acknowledge the continuous encouragement and guidance received during the course of this research from my advisor, Dr. Paul Jones. I am also indebted to Drs. Leslie Callahan and Paul Wright for their critique of the research and their helpful comments.

A word of gratitude must be extended to my parents. Without their unending patience and support, this research might never have reached a successful conclusion.

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SUMMARY

Many citizens desire to live in rural areas, such as satellite cities, and commute to work in dense metropolitan areas. However, the present forms of mass transportation available for this type of travel are inadequate, time-consuming, and costly. The primary objective of this research was to formulate a methodology for generating and comparing alternative modes of public transportation between satellite areas and major metropolitan areas. An underlying purpose was to demonstrate the diversified data requirements, to communicate the various obstacles and critical assumptions, and to identify the means for improving public transport to satellite areas.

The solution procedure consists of a twelve-step process in which a method of generating alternatives is developed and an evaluation scheme is determined. Alternative services are constructed and then compared and contrasted using the evaluation model. A service alternative evolves from the screening process. An example is modeled and solved for commuter transportation from Gainesville, Georgia (satellite area) to Atlanta, Georgia (metropolitan area).

This type of problem had previously remained untested and unsolved. The results presented indicate the usefulness and success of the solution procedure.

One of the major conclusions of the research is that transportation to a satellite area can be instituted with relatively few commuters. In addition, traditional transportation analysis techniques

are neither directly applicable nor useful in estimating "latent" demand for satellite commuter transportation. When suitably applied, public transit systems can compete effectively with automobile commuting, decreasing total travel time and trip cost.

CHAPTER I

INTRODUCTION

Many citizens desire to live in rural areas and take advantage of outdoor life. At present this requires living long distances from the city center and often requires long commute distances and times. Recent planning efforts focus on the satellite city concept in which new communities are located 15 to 70 miles from major urban areas. These satellite cities are surrounded by underdeveloped land and offer an approach to rural living that can be attractive to urban dwellers. A major deterrent to satellite city development is transportation. Long automobile trips prove to be unproductive and slow, particularly when they enter the stream of urban rush hour traffic. Existing forms of public transportation are inadequate, time-consuming, and costly. A key element to the successful development of satellite cities is the provision of fast, comfortable, convenient, economical public transportation between the satellite community and a central city.

Historical Setting

In recent years, most large central cities have been losing employment and population, both relatively and absolutely. Without much question, the overwhelming impact of technological changes on urban locations or structure has been to reduce urban densities and to decentralize or disperse urban functions.

Today many suburban communities have no public transportation

at all. A whole generation is maturing that knows nothing but automotive transportation.

The ability of Americans to afford decentralized residential locations, private yards, and automobiles has strengthened the trend toward urban dispersal. The technological and economic developments have clear implications for the structure and organization of American metropolitan areas. For example, as urban employment opportunities and residences become still more dispersed, the city center will become increasingly specialized in office, white-collar, and service activities and less and less a locale for manufacturing, transportation, and other blue-collar jobs.

The growth of the city was at one time restricted to its corporate limits; but due to the advent of quick, efficient, and reliable automotive transportation, growth in the fringe areas has increased significantly. Today growth is complicated by a combination of disorderly suburban development with the addition of an influx of new towns.

Instead of easing transportation problems, dispersion tends to encourage more extensive use of automobiles with a resulting increase in traffic intensity. It is clear that we have reached or are reaching the limits of automotive travel in terms of the high cost of congestion and the social cost of still more freeways. The future may well depend on creative development of new public transit services.

The concept of the new town is panacean in nature--small-town city life located in the rural country separated from the major metropolitan area. This life-style pledges freedom from the hustle-bustle

polluted, congested, and crime-ridden city. The primary problem that satellite new towns encounter is their function as an economically independent borough. To achieve this goal, the new town is forced to compete with the existing metro area for light industries and commercial activities. Failing in this endeavor, the majority of its residents are forced to depend upon the metropolitan area for its job capabilities--enter the transportation problem. In fact, efforts to create economically independent new towns have invariably failed. If new town developers were to recognize the critical transportation problem and supply some form of fast, convenient public transportation from the satellite area to the metro area then new town growth may be greatly accelerated.

The Government of Stockholm (Sweden) recognized this problem at the end of World War II when the population influx to metropolitan Stockholm was much greater than had been expected and the density of population in the suburbs began to build up. The planners proposed the development of suburban units (semi-satellite towns). Each unit would have its own shopping centers and cultural facilities, and most neighborhoods would be connected to the center of the city by extensions of the local railway system. By 1963 there were 18 such communities, with a total population of nearly 250,000, and five more under construction. The neighborhoods ranged in distance between 20 and 45 miles from downtown Stockholm. Notable among these are Vällingby on the western side of the city and Farsta in the south [29].

Some 23 years later, the citizens of Reston, Virginia, a satellite new town about 20 miles northwest of Washington, D.C., launched

a commuter bus operation between a central city and a satellite area. Columbia, Maryland, a satellite new town about 15 miles southeast of Baltimore, Maryland and 25 miles northeast of Washington, D.C., was the first new town to recognize transportation problems in its formative years.

Nuns' Island, a 1,000-acre tract in the St. Lawrence River only six minutes from Montreal's business district by car or bus, was the first North American satellite "new town-in town." However, in this community no thought was given to external transportation and the individual residents shoulder the burden of mobility and accessibility to Montreal [25]. Recently the Fly-In Concept has been advocated for access to new industrial parks. The rapid increase in interest in this concept prompts speculation about the ultimate development of the fly-in city--a complete urban center built around the runway as Main Street. This is already taking place in a haphazard fashion around major airports [20].

Purpose of Research

The primary purpose of this research is to formulate and illustrate a methodology for analyzing and comparing alternative modes of public transportation between satellite areas and major metropolitan areas. The underlying object is to (1) demonstrate the diversified date requirements, (2) to communicate the various obstacles to be overcome, (3) to identify the critical assumptions that need to be made, and (4) to identify means for improving public transportation to satellite areas. The results of this research can be used by city

planners, transportation planners, and new town developers to identify, describe, and estimate the costs of needed transportation services.

CHAPTER II

METHODOLOGY

Technical Literature

Technical literature devoted to improving public transportation to satellite areas tends to focus on single transportation modes. Because of their uni-modal viewpoints, most transportation studies overlook important considerations that have positive potential impacts. For broad multi-modal considerations the results of past studies need to be "pooled" and new techniques developed to form a suitable procedural and analytical methodology.

The literature of interest falls into two categories: transportation investigations and demand analysis. Transportation works consist of intracity transportation and non-commuting intercity transportation investigations. Demand analysis pertains to the means by which ridership or patronage estimates are forecasted.

Transportation Investigations

The most authoritative study on non-commuting intercity transportation is that of Meyer, Peck, Stenason, and Zwick [63]. This research was conducted in the mid-50's and concentrated on long-haul intercity movement using rail, bus, air, and automobiles. Their work pertains to trip lengths well over 200 miles in distance and thus cannot be termed "commuter-length." Cost estimates were made for various transportation modes on a seat-mile basis. To estimate rail costs, for example, Meyer et al. divided expenses into a number of different

categories, such as maintenance of way and structures, station costs, maintenance of equipment, traffic, and transportation. Using Class I railroad companies, regression analyses were performed for each category and an associated cost was determined. Employing statistics from bus companies and airlines this same methodology was used to calculate bus and air operating costs. Modal comparisons were made on the basis of cost per seat-mile for equal trip lengths and equal passenger loadings.

Although this work is very extensive, there are three principal drawbacks:

1. The quality of service for the different modes are not the same. No recognition was given to service quality.
2. The interest rate used was only 6 percent.
3. The equipment hypothesized for the different modes is no longer appropriate.

In a development quite similar to Meyer et al., Theodore E. Keeler [49] examined bus, rail, air, and auto costs for short-haul intercity movement between 100 and 500 miles. His study, conducted in 1968, employed the same methodology as Meyer et al. for cost development. He used regression techniques to estimate costs. In comparing modes, Keeler used seat-mile costs and travel time ratios for equal trip distances and passenger loadings. Travel time was used in combination with the value of time for modes where trip times were significantly different. However, non-quantifiable factors such as comfort, frequency of service, travel time variability, and safety were excluded from the comparison. An interest rate of 10 percent was used in the

analysis. In deriving rail costs, Keeler used partial and full crews. He urged that more reasonable work rules be legislated.

For intracity transport Meyer, Kain, and Wohl [62] in 1965 examined bus operations and rail rapid transit systems in many combinations and compared them to automobile transportation in terms of travel cost, travel time, and convenience (transfers). Maximum line-haul distances of 15 miles were analyzed. Bus and rail costs were determined on the basis of cost data from five or six selected cities. The individual costs were summed in a linear equation and total costs were computed. The major drawbacks of this work include:

1. Demands were arbitrarily chosen.
2. Cost data borrowed from six cities should only be used as a guideline not as a basis for determination.
3. The overall analysis is heavily bus oriented.

More recent research relating to intracity transit was performed by Thomas B. Deen and Donald H. James [22] on four types of bus and rail service operations. Their research, conducted in 1969, was limited to a line length of 12 miles. Hypothetical bus and rail systems were described so that each provided identical services. Relative costs for providing service varied depending upon line length, proportion of the line requiring subways, and passenger loadings. Sensitivity of costs to rising wage rates and variable interest rates were also examined. The major weakness of this work is that it used arbitrarily selected patronage levels.

The Northeast Corridor Transportation Planning Series [58, 87] is a transportation corridor analysis for various modes in the urbanized

area between Washington, D.C. and Boston, Massachusetts. It was extensively investigated during the mid- to late-60's and it is probably the most thorough and useful study performed to date. Many modes were investigated including high-speed rail, bus, auto, and air. Within each mode different types of services were analyzed. Most of the proposed systems were of the state-of-the-art variety, but a few included developmental technology. A number of equipment development programs were supported. These programs led to the Metroliner service between Washington and New York, the Turbotrain between New York and Boston, and extensive research on tracked air cushion vehicles, linear induction motors, and other technological developments.

Cost data were obtained predominantly from manufacturers. Each mode was developed on the basis of operating and passenger costs. Comparisons between equipment types were performed using travel cost (cents per seat-mile) for equal trip lengths. Demand for each vehicle type was assumed to be large enough to completely fill one vehicle-unit.

Demand Analysis

Demand or ridership is an important factor in improving public transportation to satellite areas. Demand studies in general focus on present travel patterns and projections of these are generated solely on population growth. A new service will have an unknown demand and traditional transportation planning techniques cannot predict patronage levels.

At present some commuting occurs between satellite communities and metropolitan centers. Most commuting is by automobile because what public transportation services exist are not particularly attractive

to commuters. There are no good data to describe this process. However, where good transportation services have been installed, as in Reston, Virginia, the response has been enthusiastic. The limited available experience suggests that patrons may come from any one of the following groups:

1. Automobile drivers and passengers presently making this trip who may be convinced to use a new service.
2. Satellite dwellers who may be attracted to job opportunities in the urban area.
3. Residents from other parts of the urban area who may be attracted to the satellite area as new residents.

It is very difficult to accurately estimate the number of riders from each group and the reliability of these figures is uncertain.

In the Northeast Corridor Study, traditional transportation planning techniques were employed to estimate patronages and modal splits based upon observed travel data. However, traditional transport planning is performed with models relying on inputs such as present travel demand. The model approach generally follows the five-step urban transportation planning process. Performed in this order, they include: (1) land use models, (2) trip generation, (3) trip distribution, (4) modal split, and (5) traffic assignment. The model approach can be used in certain cases where only minor changes in transportation service are expected. Trips are generally distributed over a demand area using a form of the Gravity Model which presumes that trip origins and destinations are matched on the basis of their relative magnitude and the distances between them. The Gravity Model is inappropriate in

analyzing satellite transportation because:

1. It does not take into account the impact of quality of service on demand.
2. It must be calibrated on the basis of observed travel patterns.
3. It cannot predict the future demand of a new service.

Two basic alternatives remain: one is to estimate patronage figures based on travel surveys and marketing surveys, and the other is to arbitrarily select ridership figures. The Northeast Corridor Analysis approached patronage attracted to each mode in two steps. First, total demand for transportation service was estimated from demographic characteristics including primarily population and income. Then the availability of transportation services was determined and distributed over the various modes using conventional modal split techniques.

In the recently completed Atlanta-Macon Corridor Study (1975), Alan M. Vorhees and Associates [108] estimated travel demand based purely on total population in the impacted counties. A modal split model was calibrated according to present commuting patterns. The study team selected different patronage levels ranging from 2,500 to 20,000 passengers per day for the proposed rail services. With each patronage level, an appropriate level of service was adopted. The two major weaknesses of their work were (1) the equipment chosen for the proposed services were unrealistically expensive, and (2) the high patronage forecasts were unfounded. As a result of these two problems, high fares and large numbers of riders were needed to offset expensive equipment costs. Had low-cost equipment been considered in the

feasibility study, lower patronage levels would have been acceptable and the service may have proven to be economically feasible.

It is desirable to consider a mode of operation that can exist with low patronage levels and a small capital investment but yet grow incrementally as demand grows. In dealing with incremental demand it is possible to use single units of equipment (i.e., one bus, one train, one airplane) and expand the proposed service. Therefore, it is recommended that a service be adopted with the following characteristics: (1) fixed costs are at minimum levels, and (2) variable costs increase proportionally with demand. Throughout this analysis, small units of demand are considered for each proposed service. It is assumed that commuter service is instituted with relatively few commuters and large volume demand is not necessarily prerequisite to success. If a minimum ridership level produces successful operation, then any higher patronage will not yield different results.

Service Ownership

Transportation system costs can be separated into two parts: costs to the operator and costs to the passenger. Costs to the operator consist of capital costs, operating costs, and risk costs. Risk costs directly influence the operator's profit margin. For a stable, low-risk operation, low profit can be tolerated; but where large risk is involved, high profit is needed. Costs assigned to passengers include: fares, travel time costs, risk costs, comfort costs, and stability or service longevity costs. Travel time costs may be advantageous or detrimental depending on travel time. Risk costs pertain to the amount

of safety built into the particular mode. Stability costs relate to the longevity of the service: its reliability and dependability.

A commuter service can be instituted and controlled in the following ways:

1. Publically owned and operated (e.g., by a municipal government).
2. Privately owned and operated (e.g., by a new-town developer).
3. Owned and operated by an organization with a charter service agreement (e.g., by a church, civic group, or commuter club).

For purposes of comparing the alternatives, it is desirable to consider minimum cost as the primary objective. A commuter club (case number 3) minimizes expected cost and risk by requiring a long-term commitment from its riders to use the service. The average load factor of patrons will be relatively stable and therefore costs will be accurately predictable. In addition, lower costs can be achieved as the club assumes the task of administering the service; some of the administrative functions are performed by the riders. For these reasons, a commuter club service-ownership arrangement was used in the analysis.

Method of Procedure

The methodology developed for improving public transportation to satellite areas from a metropolitan area includes the 12 steps shown in Figure 1. The process is an iterative one beginning with the establishment of specific logic and preparation of data on the geographic setting. Candidate services are nominated and described in sufficient detail to generate data for evaluation. Thereafter the

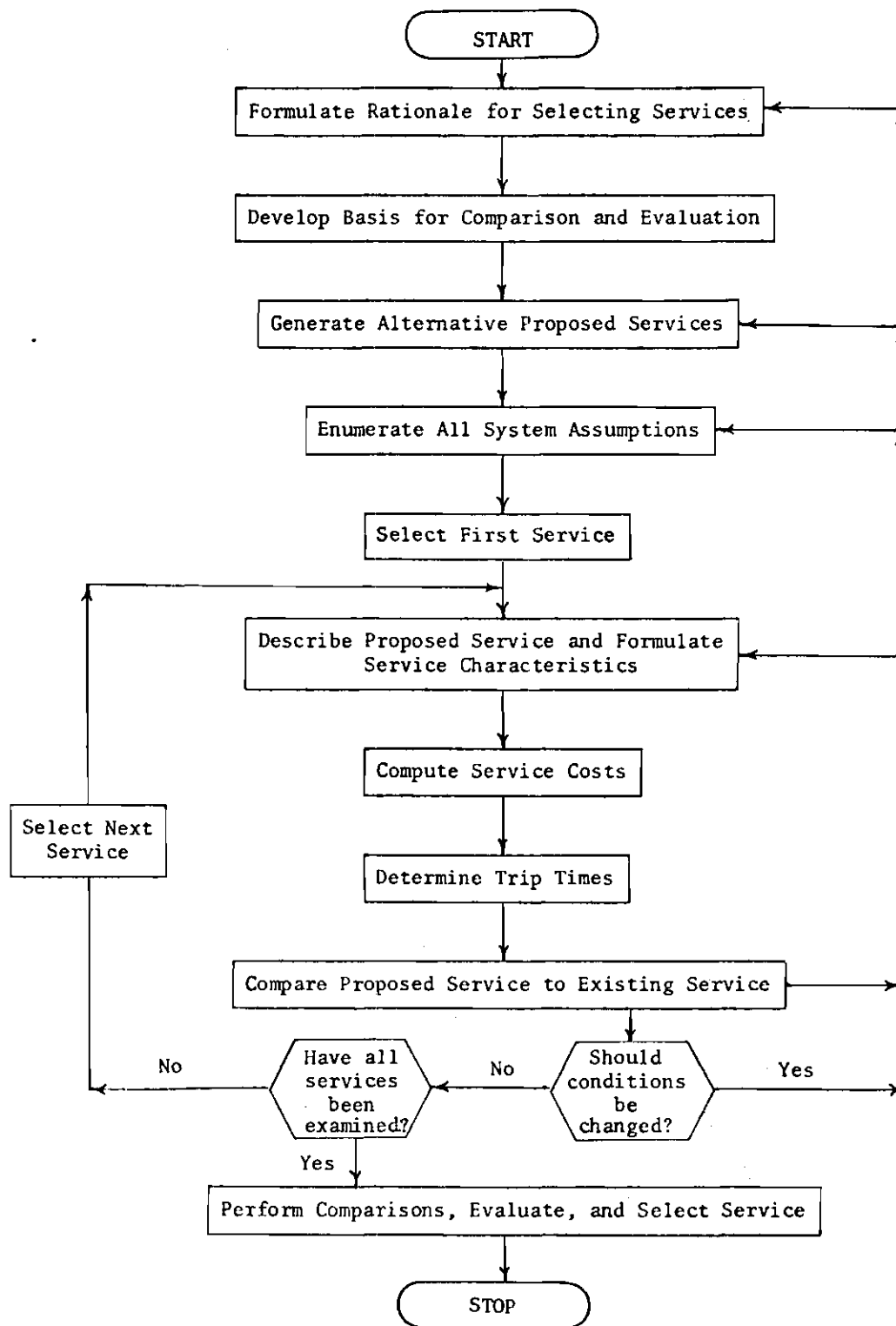


Figure 1. Information Systems Methodology

alternative services are compared and the preferred service is identified.

The specific steps in the procedure are:

1. Formulate Rationale for Selecting Services. In this step a methodology or system for selecting modes or proposed services is developed according to specified criteria. There are specific determinants that will limit the admissible systems. These include:

- (a) The technologies and equipment to be used in the service.
- (b) Total travel time and/or total travel cost need to be competitive with the predominant existing mode in the travel corridor.
- (c) The natural transportation facilities available and present travel patterns.
- (d) The size of capital investment available.
- (e) The patronage levels required for an appropriate level of service.
- (f) Destinations of the satellite area patrons in the urban area.
- (g) Distribution capabilities of the proposed service.
- (h) Service function.
- (i) Ease of implementation.

2. Develop Basis for Service Comparison and Evaluation. This step involves determining the appropriate evaluation factors and selecting a standard against which new services can be compared. In comparing and contrasting modes, there are two distinct types of evaluation factors: quantifiable factors and non-quantifiable factors. Quantifiable factors include total travel time, total travel cost, and commuter value

of time. These factors can be developed using the following equations:

$$\text{Total Travel Time } (W_i) = T_{i1} + T_{i2} + T_{i3} + T_{i4} + T_{i5} + T_{i6}$$

where

W_i = Total Travel Time for alternative i

T_{i1} = Auto Trip Time to origin station for alternative i

T_{i2} = Transfer Time (including waiting and loading time) for alternative i

T_{i3} = Proposed Service Trip Time for alternative i

T_{i4} = Transfer Time to Transit (including loading and unloading time) for alternative i

T_{i5} = Transit Trip Time for alternative i

T_{i6} = Walk Time to Destination for alternative i

$$\text{Total Travel Cost } (E_i) = C_{i1} + C_{i2} + C_{i3} + C_{i4} + C_{i5}$$

where

E_i = Total Travel Cost for alternative i

C_{i1} = Auto Travel Cost for alternative i

C_{i2} = Proposed Service Trip Fare for alternative i

C_{i3} = Transit Fare for alternative i

C_{i4} = Parking Cost for alternative i

C_{i5} = Tolls for alternative i

Combining total travel time and total travel cost with the commuter value of time, a third evaluation measure can be derived. This measure is called "equivalent travel cost" and is used in comparing two services. The equation for equivalent travel cost is as follows:

$$\text{Equivalent Travel Cost} = E_i - E_j + V \cdot (W_i - W_j)$$

where V = Commuter Value of Time.

Travel time and travel cost are only part of the factors which are considered in the decision between alternative services. Also of concern are non-quantifiable factors. These include, but are not limited, to the following:

1. Convenience (transfers)
2. Comfort
3. Frequency of Service
4. Travel Time Variability
5. Service Flexibility
6. Service Implementation
7. Service Reliability
8. Safety
9. Available Free-Time

These factors are introduced in a subjective manner during the evaluation process.

For comparing alternative services, a standard or yardstick is required against which new services can be evaluated. The predominant mode existing in the travel corridor is used as a standard or base in the comparisons. The automobile normally is the predominant mode used by commuters. Modal split determinations are based on taking travelers from the predominant mode.

When comparing proposed services, the predominant mode is compared with all alternatives in pairwise fashion until a "better"

service is found. At that time, the proposed service is pairwise contrasted with all other services until the superior service surfaces. Equivalent travel cost is the primary means by which alternative services are compared and contrasted, however, where equivalent travel cost differences between services are small non-quantifiable factors are taken into account. Each factor is weighted equally and the service with the higher number of positive non-quantifiable factors prevails as the "better" service.

3. Generate Alternative Proposed Services. This step requires investigating all alternative services and identifying the more promising possibilities. The rationale for selecting services established in Step 1 serves to limit acceptable alternatives. Selection of alternative modes can now be divided into two parts: existing modes and developmental systems in progress. Service alternatives evolve from a screening process which examines the modes with respect to the following:

1. Guideway
2. Propulsion
3. Equipment (vehicle)
4. System Control

Consider first the guideway. Two alternatives are available: use existing guideway or construct new guideway facilities. Guideway costs have a very close relationship with volume. The incremental volume approach will not support major investments in guideway, however, as demand grows, a guideway investment can be attractive. It is therefore important to be alert to opportunities to modify services once demand

begins to grow.

Consider next propulsion. Propulsion may consist of any of a variety of options, e.g., internal combustion and electric power. The propulsion system directly influences vehicle-type, line-haul travel time, and top speed. The travel time requirements of the system are known from Step 1 and will serve to limit acceptable propulsion schemes. Selection of the vehicle-type is now restricted to those which are compatible with both the guideway and propulsion systems. Finally, consider system control. System control affects travel time and travel cost. Travel time influences both speed and headway. Manual control can be costly in manpower, but automated control typically requires close headways to be economical and therefore high passenger volumes. The requirements of each type of system control further constrain the service alternatives and their selection.

To summarize, the process of generating alternative services using the limits set in Step 1 consists of two steps: (1) generate alternative services, and (2) screen the alternatives using the criteria developed above. Alternatives are normally placed in a sequence for analysis. This sequence can be random.

4. Enumerate All System Assumptions. This step describes the assumptions common to each alternative system and outlines the proposed service for the entire system. Assumptions may include but are not limited to the following:

- (a) Hours of operation
- (b) Route or routes to be followed
- (c) Geographical areas served

- (d) Interest rate used
- (e) Specific distribution interface

5. Select First Service. This step selects the first service on the list to start the analysis.

6. Describe Proposed Service and Formulate System Characteristics. The description of the proposed service and system characteristics relate to the microscopic nature of the service--the specifics of the service. The overall methodology of modal development is identical for each proposed service, but individual determinations, such as travel time and travel cost, may vary from alternative to alternative. This step may include the following:

- (a) Actual route or routes followed
- (b) Station locations
- (c) Peak hour service and service frequency
- (d) Acceleration rate
- (e) Deceleration rate
- (f) Top speed
- (g) Equipment type
- (h) Fleet size
- (i) Load factor
- (j) Maintenance equipment and service

7. Compute Passenger and Operator Costs. Costs to the passenger and to the operator are determined here. In the computation of operating costs, three different options may be pursued: (1) own equipment, (2) charter equipment,* (3) rent or lease equipment. Operator costs

*Charter service differs from leasing in that the cost of

consist of annual capital costs and annual operating costs. They are computed using the following formulas:

$$\text{Annual Capital Cost} = A_{i1} + A_{i2} + A_{i3} + A_{i4} + A_{i5} + A_{i6}$$

where

A_{i1} = Annual station cost for alternative i

A_{i2} = Annual equipment cost for alternative i

A_{i3} = Annual land cost for alternative i

A_{i4} = Annual right-of-way cost for alternative i

A_{i5} = Annual construction cost for alternative i

A_{i6} = Annual miscellaneous costs such as depreciation, retirement, and pension for alternative i

$$\text{Annual Operating Cost}_i = f(\text{LOS}_i) = O_{i1} \cdot O_{i2}$$

where

$f(\text{LOS}_i)$ = function of the level of service for alternative i

O_{i1} = Annual number of trips for alternative i

O_{i2} = Cost per trip for alternative i

Using both annual operating and capital costs, passenger cost per trip is determined in the following manner:

$$\text{Passenger Cost per Trip} = \frac{A_{i7} + O_{i3}}{N_{i1} \cdot N_{i2}}$$

chartering includes operator (driver), fuel, maintenance, storage, and insurance whereas leased equipment only includes maintenance and the leasee is required to supply the remainder.

where

A_{i7} = Annual capital cost for alternative i

O_{i3} = Annual operating cost for alternative i

N_{i1} = Annual number of seats moved for alternative i

N_{i2} = Average load factor for alternative i

The equation for total travel cost derived in Step 2 can now be revised to reflect the computation for passenger trip costs. The equation appears below:

$$\text{Total Travel Cost} = C_{i1} + \frac{A_{i7} + O_{i3}}{N_{i1} \cdot N_{i2}} + C_{i3} + C_{i4} + C_{i5}$$

8. Determine Trip Travel Time. Trip travel times for each proposed service are computed using the simplified assumptions. Each service will undoubtedly require different assumptions and its components are calculated differently, however, the following equation will hold for all alternatives:

$$\text{Travel Time} = L_{i1} + L_{i2} + L_{i3} + L_{i4} + L_{i5}$$

where

L_{i1} = Loading time for alternative i

L_{i2} = Acceleration time for alternative i

L_{i3} = Line-haul time for alternative i

L_{i4} = Deceleration time for alternative i

L_{i5} = Unloading time for alternative i

The equation for total travel time formulated in Step 2 can now be updated to include the proposed service trip time.

$$\text{Total Travel Time} = T_{i1} + T_{i2} + L_{i2} + L_{i3} + L_{i4} + T_{i4} + T_{i5} + T_{i6}$$

9. Compare Proposed Service to Existing Service. This step may be deleted if there is no existing service, however, it should only be omitted for that reason. This comparison examines only total travel time and total travel cost between the two services. Initially it was hypothesized that a "new" service could be implemented with favorable improvements over existing service. This step is a check to ensure that this condition is met. If not, the proposed service is either deleted from the list of alternatives or computations are performed again with new operating details. Before leaving this step, the question is asked, "Should conditions be changed?" A no response transfers control to Step 10; a yes response shifts control to any of the following steps: 1, 3, 4, 6.

10. Have All Services Been Examined? The insertion of this step into the methodology serves as confirmation that none of alternative services are neglected. If the answer to the question is no, then control shifts to Step 11. A yes response transfers control to Step 12.

11. Select Next Service. The purpose of this step is to continually select proposed services from the list of alternatives until all possibilities have been examined. At that time, this process terminates and the comparisons begin. This step is omitted only when all possible services have been analyzed.

12. Perform Comparisons, Evaluate, and Select Proposed Service. The basis for comparing alternatives was established in Step 2 and it is here that we perform pairwise comparisons, evaluate the results,

and select a service.

Summary

To summarize this chapter, available technical literature of two different types were examined and part of this research influenced the methodology that was developed. Although the methodology is generally stated, it has numerous applications. The general development, in fact, is more powerful in this form. The flexibility of the methodology encompasses wide latitudes as borne out by the illustrative example. In the chapters to follow, the model is illustrated for a particular application. An area is selected and alternative services are generated, analyzed, and evaluated according to the methodology. Finally, an alternative service is selected.

CHAPTER III

ILLUSTRATION

A specific example was developed and analyzed to demonstrate the analytical method. The thesis is that commuter service can be developed from a satellite area to a central city if the service is sufficiently attractive, convenient, and reliable.

A satellite city opportunity was sought that meets the following requirements:

1. It has a high-speed, limited-access road link between the satellite area and the metropolitan area because this will stimulate some automobile commuting and provide a guideway for automotive-type alternatives.
2. The satellite area should be a small town that offers some attractive features to urban residents such as recreational, educational, and commercial opportunities. There should also be a potential for population growth.
3. The satellite area should be within a 50-mile radius of the central city. Currently 2 percent of all commuting is performed beyond this limit.

Gainesville, Georgia was selected as the satellite area in need of transportation linking it to the Atlanta economic area. A description of Gainesville follows.

Gainesville

The city of Gainesville is located in the Georgia Piedmont Region approximately 50 miles northeast of Atlanta. Since 1821, Gainesville has served as the county seat for Hall County, and as a sales and service center for the Georgia Mountains Region. Since World War II, Gainesville has emerged as a regional trade and industrial center. The incorporated area of Gainesville comprises over 12 square miles situated near the geographic center of Hall County. The Gainesville urban area encompasses over 52 square miles, and includes approximately 34,000 people.

In the early part of the century, Gainesville's economy developed steadily with the influx of several major textile producers. After World War II, poultry growing and processing replaced the textile industry as Gainesville's predominant source of income. Currently, Gainesville is diversifying with the addition of the manufacturing of electric motors, mobile homes, furniture, and leather goods.

Recent trends in the Gainesville area have included a decline in the importance of agriculture, a doubling of non-farm employment, more diversification of industry, and the emergence of Hall County as a national center of poultry production.

Population

At present, the population of Gainesville, residing within the corporate limits exceeds 15,000 persons, and accounts for approximately 26 percent of Hall County's total population. Until 1960, the population had increased steadily for half a century.

During the past decade, the total population of Gainesville

declined by over 6 percent, and the city's proportion of the total county population decreased by 7 percent. However, for this same time period, Hall County continued to grow at a rate significantly higher than the state of Georgia as a whole. This pattern of area growth reflects the declining dominance of the central city, and illustrates a trend in the Gainesville area towards the dispersion of population away from the central city.

Outlying districts are growing rapidly. The Oakwood Division population increased 77.7 percent between 1960 and 1970 and the Flowery Branch Division increased 31.1 percent. Hall County's population increased 19.4 percent and the state of Georgia expanded 16.4 percent during the same period.

The 1970 census counted 53,314 white persons in Hall County, 89.7 percent of the total; 6,015 blacks, and 76 persons of other races. In 1960, 89.2 percent of the population was white.

The 1970 census counted 19,657 housing units in Hall County, 11,982 (61%) of them occupied by owners, 6,065 by tenants, and 1,610 vacant. These include vacant units for seasonal use. The Hall County building and construction business has been booming. In 1962, 358 permits were issued valued at \$2,128,516, but in 1972, 438 permits were valued at \$10,705,699.

Income

The Gainesville family income closely resembles a normal distribution with 31.8 percent of the families under \$6,000 and 23.8 percent of the families over \$15,000. The median income per household in Hall County is \$7,788 and in Gainesville is \$9,236 whereas the

state of Georgia is \$8,167.

Employment Structure

The present total employment in Hall County is approximately 25,000 persons. Of this total, 38 percent are employed in manufacturing, 48 percent in non-manufacturing, and 4 percent in agricultural employment. Since 1960 Hall County has shown an increase of 7,000 jobs. This growth has occurred predominantly in the Gainesville area in non-manufacturing employment. During this 10-year span, employment in the non-manufacturing sector accelerated at a greater rate than did employment in the manufacturing sector, and for the first time in Hall County, the total number of persons employed in non-manufacturing activities exceeded the total manufacturing employment.

Manufacturing employment in Hall County is concentrated in the production of non-durable goods--notably poultry. Approximately 1.5 million birds and 1.2 million eggs are processed weekly in Gainesville, attesting to the city's claim as the Poultry Capital of the world. A 1967 survey indicated that 38 percent of Hall County's manufacturing employment was in the food and kindred products category (including poultry related processes), compared with 11 percent for the state of Georgia. The second major area of Gainesville employment is in textiles --accounting for 29 percent of the county's manufacturing employment. This compares with 26 percent for Georgia.

The largest manufacturer in the Gainesville area is Deering Milliken which employs 1,188 workers to produce unfinished textiles. Other notable manufacturers are J. D. Jewell, Inc., Chadbourne Hoisery Hills, Swift and Company, and William Wrigley Company.

Gainesville's income distribution is bi-modal with concentrations at the low end where both poultry and textiles pay low wages, and at the upper end, where affluent urbanites from Atlanta are buying second-family homes and commuting to take advantage of the recreation facilities.

Land Use

A breakdown of current land use in the Gainesville area is presented in Table 1.

Table 1. Land Use in Gainesville

Type	Acreage	Percent
Residential	1,815	23.39
Commercial	273	3.52
Industrial	226	2.91
Public	875	11.27
Semi-public	99	1.27
Streets	734	9.46
Urban renewal area	145	1.87
Sub-total	4,167	53.69
Water areas	1,330	17.14
Vacant	<u>2,263</u>	<u>29.17</u>
Total	7,760	100.00

Source: Gainesville Planning Commission, "Gainesville, Georgia in Perspective."

Wholesale and Retail Trade

Gainesville has long been the wholesale trade center for the Georgia Mountain Area, as well as for Hall County. It now accounts for over 80 percent of Hall County's and 60 percent of the Georgia Mountain Area's wholesale trade. Retail sales in Gainesville has

grown at a higher rate during the preceding decade than Georgia as a whole. This fact is highlighted in Table 2 below.

Table 2. Retail Sales in Georgia

Area	1960	1970	Percent Change
Gainesville	43,360	89,891	107.3
Hall County	52,223	116,204	122.5
Georgia	3,924,204	7,439,130	89.6

Source: Sales Management, "Survey of Buying Power."

Table 2 illustrates the beginning of sales activity decentralization from within the corporate limits of Gainesville to the unincorporated fringe areas.

The major trend in wholesale trade is the diminishing impact of Gainesville as a wholesale trade center. This trend can be traced to increasing competition from other wholesale trade centers, and increased accessibility to Atlanta as a result of highway improvements.

Transportation Facilities

Gainesville is served by railroad facilities, bus service, truck service, and air transportation. The railroad facilities include the Southern Railway and the Gainesville Midland Railroad. The Southern Railway's main line from Atlanta, Georgia to Washington, D.C., passes through Gainesville. Seven trains are scheduled northbound, two passenger and five freight--and the same number southbound. The local freights make up in Gainesville, leave, and return daily. The Southern

also has three switch engines working daily in the yard limits of Gainesville.

The Gainesville Midland Railroad, a wholly owned subsidiary of the Seaboard Coast Line Railroad, operates daily freight schedules to and from Athens, at which point it connects with the main line of the Seaboard Coast Line Railroad. Piggy-back ramp loading and unloading is available on the Gainesville Midland Line.

Greyhound Bus Lines operate five northbound and seven southbound daily schedules through Gainesville. Two daily commuter buses provide round-trip service to Atlanta.

Three levels of truck service are available in the Gainesville area. These include (1) trucking firms which maintain terminals in Gainesville and carry both interstate and intrastate shipments; (2) firms which maintain agencies or terminals in Gainesville but offer only interstate service; and (3) trucking firms with terminals in Atlanta that offer only service to Gainesville.

The Gainesville Municipal Airport is located within the city corporate limits, one mile south of downtown Gainesville. The Gainesville Airport has two 4,000-foot runways, rotating beacon, runway lighting, and FAA approved instrument approach facility. Complete fuel (including turbine), hangaring, and maintenance service is provided by the operator, Blue Ridge Aviation, Inc. Flight instruction is also available through Blue Ridge Aviation, Inc. The location and expanding facilities of the Gainesville airport serve the needs of air transportation throughout North Georgia. Commercial air service facilities are located at Athens, Georgia, 39 miles from Gainesville,

and in Atlanta, 53 miles from Gainesville.

Major highway arteries in the Gainesville vicinity include U.S. Highway 23 and 129 and Georgia Highways 53, 60, 141, and 365. These highways provide direct or connecting links with all parts of the state, region, and country. Georgia 365 is a limited-access highway that connects Gainesville to Interstate-85 and Atlanta.

Utilities

The city of Gainesville supplies water to area residents from Lake Lanier reservoir. The city's water plant has a present capacity of 12 MGD, with the daily consumption rate averaging over 6 MGD. The previous peak consumption for the city was 9 MGD reached in August of 1972.

A secondary sewage treatment plant is located in the Gainesville area. Service is provided to city residents without a service charge. The present capacity of the treatment plant is 10 MGD with the average load approximating 5 MGD.

Electricity is supplied by the Georgia Power Company. The city's electrical network uses predominantly 12 kv lines, and is distributed by the Georgia Power Company, Jackson EMC.

Natural gas is pumped to Gainesville by the Transcontinental Gas Pipe Line Company and distributed by both the Atlanta Gas Light Company and the United Cities Gas Company.

Other sources of power available to Gainesville manufacturers include LP gas, fuel oil, and coal.

City Services

Hall County operates 27 public schools with a total enrollment

of 14,646 students, and a teaching faculty numbering 594. Three facilities for higher learning have been established in Gainesville: (1) Lanier Technical School is a vocational school with a present enrollment of 750 students, (2) Gainesville Junior College offers a two-year program in liberal arts and has a total enrollment of 875 students, and (3) Brenau College, a four-year institution with an enrollment of 565 students.

The Hall County Hospital serves as a regional medical center with 300 beds. More than 72 physicians and 25 dentists and oral surgeons serve the hospital facility. The hospital in association with Brenau College, also operates a three-year professional school of nursing. The Hall County Hospital offers a full range of medical and surgical services, an intensive coronary care unit, an Intensive Drug Abuse Care Unit in connection with a modern Mental Health Unit, and cobalt therapy facilities.

Other services provided to area residents include police protection (50 full-time city policemen and 22 full-time county policemen), fire protection (41 full-time firemen), garbage collection facilities, a public library, and a full-time licensed city engineer.

Climate

The average rainfall per year is just over 54 inches. Monthly humidity is 75 to 85 percent mornings, and 50 to 65 percent afternoons.

Recreation

Gainesville is the recreation center for northeast Georgia, and one of the most important in the state. Lake Sidney Lanier is a prime attraction for all water-oriented sports such as boating, sailing,

fishing, swimming, and skiing. Her position at the edge of the Chattahoochee National Forest and at the foot of the Blue Ridge Mountains makes it also a popular area for camping, mountain stream fishing, and hunting. The local park and recreation department caters to the interests by teaching swimming lessons and sponsoring waterskiing and camping clubs. One of the fastest growing sports in the Gainesville area is that of raising and showing horses. Numerous shows each year attract visitors and exhibitors from throughout Georgia and surrounding states.

Three motion picture theaters, with a seating capacity of better than 2,100 and two drive-in theaters with a combined car capacity of 750 are located in the metropolitan Gainesville area. Plans exist for an additional theater to be completed in one of the new shopping centers.

Complementing the recreation boom in beautiful Hall County has been the development of Road Atlanta, the South's first major road racing facility. It is located on a rolling, tree-studded 380-acre site in the scenic Chestnut Mountain community on Georgia Highway 53 near Gainesville. Road Atlanta was designed for Grand Prix type road racing and hosts the Can/Am and the Atlanta Road Racing Classic.

The Civic Building, located in downtown Gainesville, seats 1,000 for meetings and has space for 700 serving places. The auditorium at Brenau College has 1,000 seats for meetings and the Chattahoochee Country Club has 90 places for serving and meetings. The Elks Club has 150 places for serving and meetings.

Application of Methodology

Application of the analytical method to commute between Gainesville and Atlanta is illustrated below.

Step 1. Formulate Rationale for Selecting Services. The rationale to govern the selection of alternatives is based on the automobile mode because it is predominant transport mode in the travel corridor. In this step the following restrictions will apply:

- (a) Existing technologies will be used.
- (b) Both total travel time and travel cost will be competitive with the automobile.
- (c) Natural transportation facilities will be considered along with other possibilities.
- (d) Only a small capital investment will be available.
- (e) Small patronage levels will exist for each proposed service.
- (f) Small demands will exist to any one destination.
- (g) Distribution within the Atlanta metropolitan area will not be strictly confined to one mode--the Atlanta area is served by public transit.*
- (h) The service function will consist of supplying peak-hour commuter service only.
- (i) Implementation must be relatively easy, requiring no major construction.

*MARTA (Metropolitan Atlanta Rapid Transit Authority) is presently constructing a 53-mile fixed rail system to supplement its surface bus system.

Step 2. Develop Basis for Service Comparison and Evaluation.

In comparing service alternatives, quantifiable factors and non-quantifiable factors are used in the analysis. The quantifiable factor primarily used is "equivalent travel cost" which includes total travel time, total trip cost, and value of time of a commuter (\$3 per hour*). Comparisons will be performed in pairwise fashion and small differences in "equivalent travel cost" will then be judged using non-quantifiables.

Non-quantifiable factors consist of:

- (a) Convenience (transfers)
- (b) Comfort
- (c) Frequency of Service
- (d) Travel Time Variability
- (e) Service Flexibility
- (f) Service Implementation
- (g) Service Reliability
- (h) Safety
- (i) Available Free-Time

The non-quantifiable factors will carry equal weights and the service with the majority will be termed "better."

In order to accurately compare alternative services, it is necessary to compare sample trips between the cities. These sample trips represent potential large volume movements and provide more adequate comparison than by examining only line-haul capabilities.

*A modal choice study conducted from household interview data collected as part of the Chicago "Skokie Swift" Mass Transportation Demonstration Project revealed that commuters value time at \$2.70 per hour (in 1968 dollars). A figure of \$3.00 per commuter per hour is deemed reasonable in 1975.

Five destinations are chosen in Atlanta and three origins in Gainesville to yield a total of 15 sample trips. The five locations selected for the Atlanta end of the trip are: (1) Georgia Tech Campus, (2) Fulton Industrial Park, (3) Executive Park, (4) Equitable Building (in Atlanta CBD), and (5) airport terminal. These locations are illustrated in Figure 2.

The Georgia Tech campus attracts a large number of trips because of its employment, student population, and academic endeavors. Its mid-downtown location places it near the Tenth Street and North Avenue Rapid Transit stations.

Fulton Industrial Park is a rapidly growing employment center located 6.7 miles west of downtown Atlanta near Six Flags Over Georgia amusement park. Its placement is only two miles west of the Fairburn Rail Station.

Executive Park is a fairly new development, consisting of white-collar offices and professional businesses. It is located near the I-85 (North) interchange on North Druid Hills Road. The Lenox Transit Station is about 2.1 miles northwest of Executive Park.

The Equitable Building is located in the Atlanta CBD (Central Business District). This office building contains much commercial, professional, and governmental activity. The Five Points Rail Station is only three minutes by foot south of the Equitable Building.

The airport terminal at Hartsfield is the final destination point. The airport itself is Georgia's largest employer and attracts a large number of patrons. As a result, the Atlanta Airport has a transit station at its doorstep.

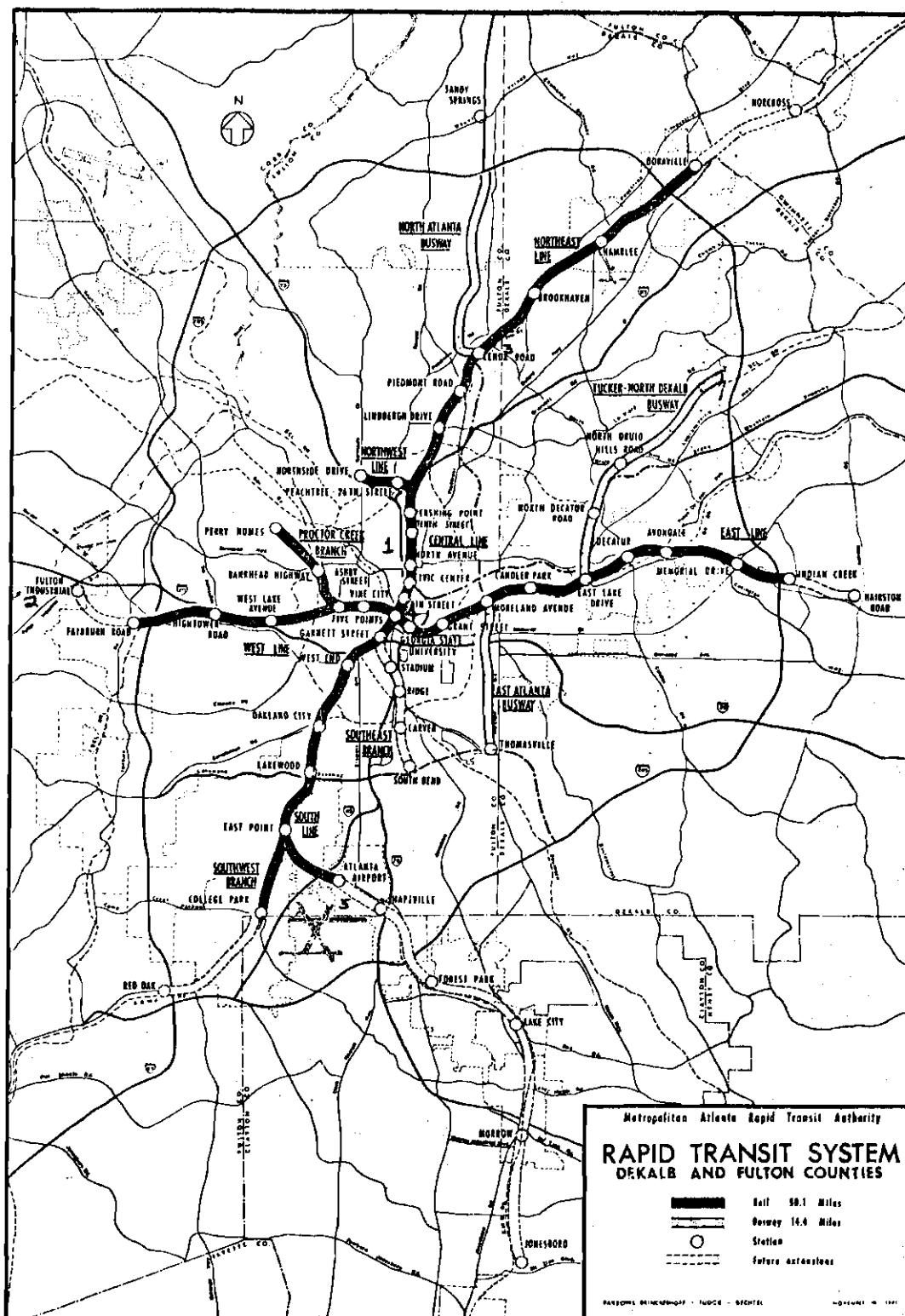


Figure 2. MARTA Rapid Transit System

The three origins in Hall County are divided equally between Gainesville, Oakwood, and Flowery Branch (Lake Lanier). New development is apt to occur around the lake so each origin is chosen using that criterion. The Gainesville origin is on Roper Road due west of town. The Oakwood origin is on Whites Mill Road due west of the Oakwood corporate limits. The final point is located east of the Lake Lanier Islands and southwest of Flowery Branch in an area known as Big Creek. These points are displayed on Figure 3 which is a map of Hall County.

Step 3. Generate Alternative Proposed Services. The rationale for selecting alternative services (Step 1) provides limiting guidelines for possible alternatives. The key limitation is that service should be instituted with a small capital investment. Combining this constraint with the one requiring state-of-the-art technologies, vastly reduces the possible choices. Consider three modes of service in the analysis: air, rail, and highway.

Some of the air alternatives may include:

- (a) CTOL (Conventional Take-Off and Landing)
- (b) STOL (Short Take-Off and Landing)
- (c) VTOL (Vertical Take-Off and Landing)
- (d) V/STOL (Vertical or Short Take-Off and Landing)

All four types of air service above satisfy the requirements of Step 1, however, operating costs--especially maintenance equipment and service--are very high for the VTOL and V/STOL aircraft leaving only STOL and CTOL-planes. In the Northeast Corridor Study, CTOL-planes operated at a lower system cost per passenger-mile than any of the other common

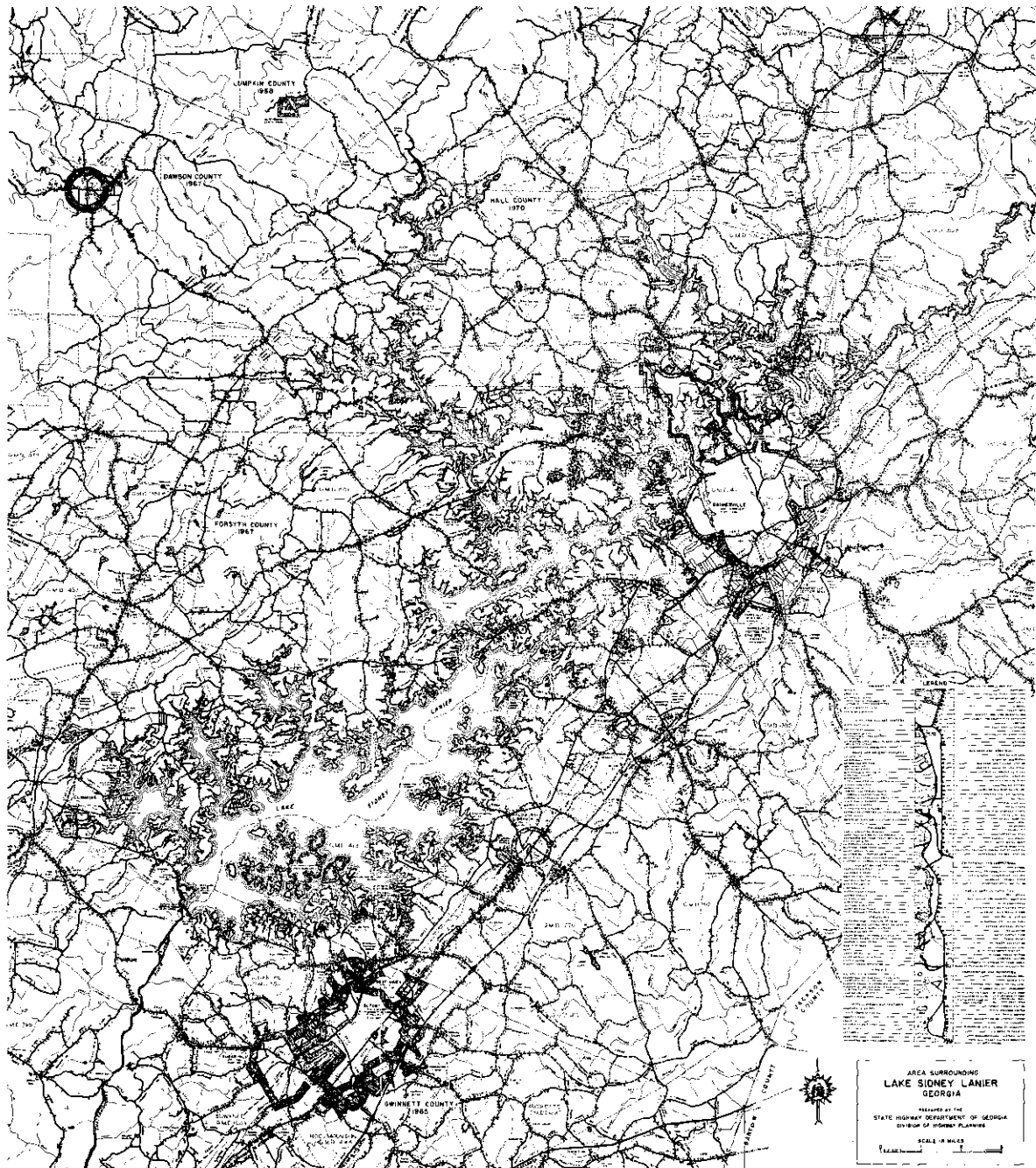


Figure 3. Map of Gainesville and Hall County

carrier modes examined except the city bus [87]. Therefore, STOL-craft are set aside due to higher costs and CTOL-planes are selected as an air alternative service.

Rail transportation is investigated. Based on the existence of Southern Railway track which provides the necessary guideway for rail service, this alternative meets the restriction on capital investments. Some of the more promising vehicular options include:

- (a) Conventional push-pull equipment.
- (b) Light rail transit equipment (e.g., manufactured by Boeing-Vertol).
- (c) Rail rapid transit vehicles (e.g., manufactured by Pullman).
- (d) Rail Diesel Cars (RDCs)
- (e) High-speed equipment (i.e., Metroliner, Turbotrain, and LRC-Lightweight, Rapid, and Comfortable).
- (f) Self-propelled dual-mode commuter cars (e.g., manufactured by Garrett).

The screening process begins with the guideway. Use existing Southern Railway track. Examine propulsion. The Southern track has neither third-rail nor overhead electrical power and therefore electrically propelled light rail and rail rapid transit vehicles are eliminated. The Metroliner, manufactured by Budd Company, requires overhead electrification and is dropped from consideration for the same reason. Investigate equipment selection. Intrinsic in this step is the notion of equipment availability. The RDC may meet travel time and travel cost requirements, but the vehicles are not generally available. The

Budd Company has not manufactured any RDCs since 1968 and there are very few throughout the country that are available for purchase. Consider system control. From Step 1 small patronage levels are expected to use this service and Southern accommodates that type of traffic today using semi-automated control and conventional push-pull equipment with diesel electric locomotives. Using the Turbotrain or LRC will overtax the present signal system. The maximum guideway speed is 79 mph and these trains are built to maintain speeds between 110-120 mph; they will not operate as efficiently at 75 mph. The dual-mode commuter car has the preceding drawbacks plus the purchase includes two propulsion systems and only one is needed. For these reasons, conventional push-pull equipment using diesel electric locomotives is selected as another alternative service.

Greyhound presently operates bus service between the two areas over a partially controlled access highway. The existing service makes eight stops along the way to Atlanta and the bus routes in and out of numerous small towns. As a result, travel times are very long. It appears that these long travel times can be improved with fewer stops and exclusive operation over a high-speed highway. A bus rapid service is proposed as another alternative service.

Van-pooling is a special service and deserves some attention here. Van-pooling supplies a personal form of transportation through the use of small vehicles such as jitneys, vans, and mini-buses. Passenger loads range from 8 or 9 for small vans up to 15 or 20 for mini-buses. It is "private" like the automobile and performs both the line-haul and distribution functions that are needed in an urban area.

Operating costs are in between those of the auto and the bus. It may have labor costs similar to those of a bus and can be operated by the "average" driver. Travel times for the van closely parallel those of the auto and roadway delays have the same impact as they do to the automobile. It was eliminated from consideration because MARTA supplies adequate distribution throughout the Atlanta area and the travel time is inherently longer than the automobile because of multi-pick ups and deliveries (Step 1 restrictions).

Step 4. Enumerate All System Assumptions. These include:

- (a) Hours of operation: 6:30-7:30 a.m. and 5:00-6:00 p.m.
- (b) Route: use I-85 and Ga. 365 for bus service, Southern tracks for rail service, and Gainesville Municipal Airport for air service.
- (c) Serve areas of Gainesville, Oakwood, and Flowery Branch.
- (d) Use interest rate equal to 10 percent.*
- (e) Use the MARTA Rapid Transit and surface bus system for distribution throughout Atlanta (see Figure 2).

Step 5. Select First Service. The services are ranked in the following order: bus, rail, and air and they will be discussed in that order. Separate chapters will be devoted to each alternative service: Chapter IV will investigate the proposed bus service, Chapter V will examine the rail service alternative, and Chapter VI will consider air service. In Chapter VII the comparisons will be performed and evaluated and a service will be selected. Chapter VIII presents the conclusions.

*As of May 21, 1975, the prime lending rate is 7.25 percent.

CHAPTER IV

BUS SERVICE

The commuter bus service is the first of three alternative modes for transporting people between Gainesville, Georgia and Atlanta, Georgia that was investigated in detail. The material is presented in four parts. First, the Service Description will present the details of the proposed service and then Service Characteristics peculiar to the bus mode will follow (Step 6). Costs will be determined next (Step 7), and travel time calculations will be performed (Step 8). Finally, comparisons between the proposed service and existing service will be made (Step 9).

Step 6. Describe Proposed Service and Formulate Service Characteristics.

Service Description

The commuter bus service will operate between Gainesville, Georgia and Doraville, Georgia, a distance of 39.3 road miles. At Doraville, commuters will transfer to MARTA thus utilizing the rail system for its distribution capabilities throughout Atlanta. There will be a total of three stops in Hall County. Each intermediate stop will last for two minutes. These three stops are located to be accessible to a large number of potential riders.

In the morning the bus service will start at Gainesville and travel on Ga. 365 to I-85 and then on towards Doraville, Georgia. To

reach the MARTA station, the bus will leave I-85 at the Oakcliff Road-Northcrest Road exit which directly precedes I-285. At the MARTA station passengers will debus and board MARTA trains to reach their final destinations.

Commuters using this service will travel at high speeds and will ride in air-conditioned comfort. The bus drivers will be professional and certified by the Georgia Department of Transportation, Division of Motor Vehicle Licensing. Four daily trips total will be made by each bus--two trips during the morning rush hour and two trips in the evening rush hour. As ridership increases more buses will be added and hence the frequency of service increased. The service will be in operation five days a week, 52 weeks per year, for a total of 254 days each year.

Service Characteristics

Service characteristics consist of travel costs, trip times, station locations, and metropolitan trip distribution. Two approaches can be pursued in determining bus operating costs. The purchased cost of a 47-seat bus equipped with air-conditioning is \$56,000. The expected life of a bus is 15 years with a salvage value of \$1,000. Maintenance costs will vary between 5¢ and 7¢ per mile. The 30-gallon diesel fuel tank will last 180 miles based on 6 mpg; diesel fuel presently costs 37¢ per gallon to MARTA and will probably cost 45¢ per gallon to the "Commuter Club" unless a large-quantity purchase is made.

The other alternative is to charter this type of bus for 70¢ per mile which includes the driver, fuel, maintenance, and insurance.

Comparing both alternatives, it is cheaper to charter the bus and this policy will be assumed.

Travel times are calculated using the average equations of motion:

$$V = at$$

$$V_f^2 - V_o^2 = 2(0.682)as$$

$$S = 0.5 (1.467)at^2 + 1.47 V_o t$$

where

S is the distance traveled in feet

V is the velocity expressed in miles per hour (mph);
subscripts V_f and V_o refer to final and original
velocities

t is the time in seconds

a is the acceleration of the bus in mph/sec

The average line-haul velocity for the bus will be 70 mph. Although law limits the maximum speed on highways to 55 mph, buses are assumed to receive preferential treatment. Buses are more efficient passenger-transporters, pollute less air, and lower highway congestion. The acceleration rate of the bus will be 0.875 mph/sec and the deceleration rate will be 4.2 mph/sec.* Both the acceleration and deceleration rates are averages over the entire acceleration and deceleration period.

*The acceleration and deceleration rates are consistent with the work performed by Meyer, Kain, and Wohl in Reference 62.

MARTA will play a vital role in solving the distribution problem at the Atlanta end of the trip. Transfer from the bus to MARTA will be made at the Doraville station with little delay. The bus will drive up to the station entrance (exit) and the passengers will debus (board) in front of the MARTA station as in the kiss'n ride mode.

Station location nearby the traveled route greatly influences travel times. Intermediate stops will be selected no more than a quarter-mile from Ga. 365. Two minutes will be the total stop time. This time includes the time from the road to the station, and back again, in addition to boarding and debording time. The two minutes, typically, may be divided into chunks of 40 seconds each. The next section will be more definitive with respect to station location.

Station

Location

The commuter bus service will have three stations in Hall County. The Gainesville-Oakwood-Flowery Branch "Metro Area" stretches approximately 19.2 miles linearly and the key to the station location problem will be to minimize bus delays from the traveled route to the station. All stations will be located near the diamond interchanges on Ga. 365 to reduce delays associated with the station stops.

The three stations will be nearly equidistant from one another. The Gainesville station will be placed at the Ga. 365 and New Holland interchange, 0.45 miles north of U.S. 23 and Ga. 13. The placement of this station near the interchange guarantees easy ingress and egress

for the bus to Ga. 365 as well as moderate accessibility for the bus passengers. This location is northeast of town where the new Gainesville growth is occurring. In addition, this location is close to the Gainesville business district, but yet, far enough away to remain out of the congested traffic streams.

The second station will be located 1.8 miles east of Oakwood, Georgia at the interchange of Ga. 365 and Ga. 352. In locating near the interchange, excellent accessibility is afforded both to the bus as well as to the prospective passengers. Lanier Tech, Gainesville Junior College, South Hall High School, and Oakwood School are located very close to this interchange. The Oakwood station will be located 7.3 miles from the Gainesville station.

The third station and the last one in Hall County will be located 3.55 miles southeast of Flowery Branch, Georgia. There is a slight dilemma in locating this final station. Ga. 365 access is limited to two interchanges between the Hall County line on the south and Oakwood, Georgia (Ga. 352) on the north; this distance along Ga. 365 is over 8 miles. The southernmost interchange (Friendship Road) is 0.9 miles north of the Hall County line and the other interchange (Spout Springs Road) is located approximately 3.1 miles north of the Friendship Road interchange. The new housing developments to be constructed in southern Hall County will undoubtedly surround the Lake Lanier Islands as is already in evidence today. On the other hand, Flowery Branch is a quaint, old town and may very well attract "new towners" as a result of its small-town, rural living conditions. People living near Flowery Branch will be able to select station 2

about 4.1 miles north on Ga. 365 from Spout Springs Road or station 3, about 3.1 miles south on Ga. 365 from Spout Springs Road. Discounting Lake Lanier Islands and the parks, yacht, and sailing clubs, approximately 4.5 miles from Friendship Road (station 3) lies the Buford-Sugar Hill area in Gwinnett County; this area is expected to have over 10,000 people in 1990 and may well be another area full of prospective riders. To accommodate this conflicting demand station 3 will be located 7.24 miles south of the Oakwood station (station 2).

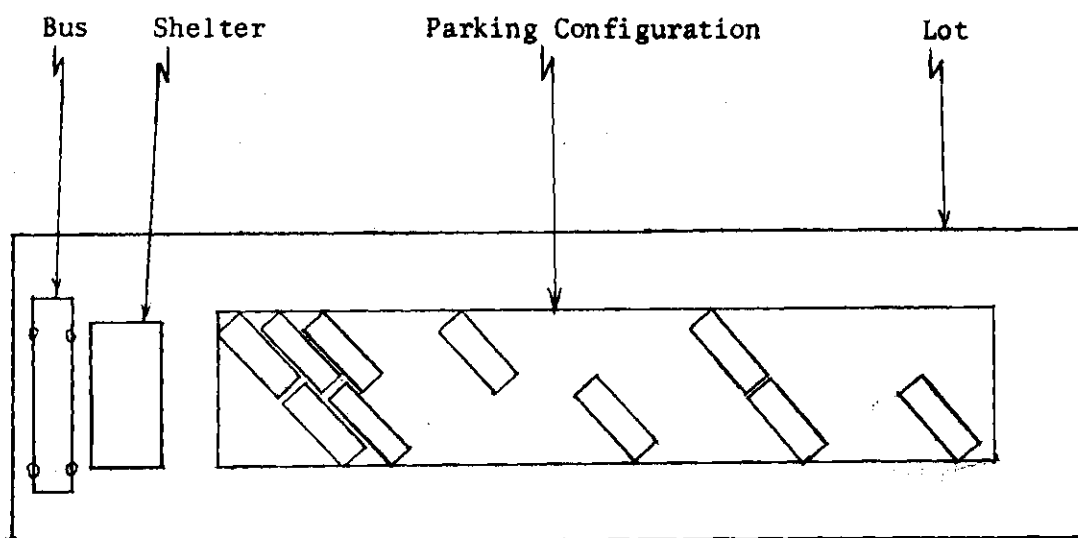
Design

The design of a bus station is governed by the functions it will serve and these functions, in turn, will determine its land requirements. Each station will provide shelter against inclement weather, free park 'n ride spaces, parking area for the bus, and area for kiss'n ride maneuvers. Figure 4 illustrates the typical layout of a station. The Appendix explains the design in detail with the respective land requirements and their associated costs.

Step 7. Compute Service Costs. Service costs can be segmented into two subdivisions: fixed costs and operating costs. Fixed costs include such items as land cost, construction cost, installation costs, electricity, etc. The operating costs include all costs associated with chartering the bus. It is significant to separate these costs as further expansions of the bus service will have no effect on fixed costs but only on operating costs.

Fixed Costs

These costs are discussed in depth in the Appendix. The total sum of the fixed costs on an annual basis will be \$8,628.33.



Scale: 1" = 40 ft

Figure 4. Typical Bus Station Layout

Operating Costs

Initially, operating costs of the commuter bus service will be minimal due to the limited schedule. There will be four round trips per day with each round trip totaling 79 miles. Total miles traveled each day will be 316. At 70¢ per mile for chartering the bus service, the cost will be \$221.20 per day or \$56,184.80 on a yearly basis.

Passenger Costs

The total service costs include both fixed and operating cost and these costs will be passed on directly to the passengers in order to avoid any losses. The fixed and operating costs sum to \$64,813.13

per year. Table 3 illustrates the expected cost per passenger per trip for three arbitrary load factors based on a capacity of 47-seated passengers, and four trips per day. No cross-commuting is assumed.

Table 3. Bus Service Passenger Costs

Load Factor	Passengers		Cost per pass
	per day	per year	
100%	188	47,752	\$1.18
80	152	38,608	1.45
60	112	28,448	1.97

The costs shown under the far right-hand column represent breakeven costs which must be charged to cover all expenses. A fare of \$2.00 will be charged.

Step 8. Determine Trip Travel Times. Table 4 below lists the trip travel times from each commuter station to the MARTA station in Doraville, Georgia.

Table 4. Commuter Bus Service Travel Times

Station	Distance from Gainesville (in miles)	Travel Time from Gainesville (in minutes)
Gainesville	0	0
Oakwood	7.3	7.1
Flowery Branch-Lake Lanier	14.55	14.1
Doraville	39.3	39.7

Step 9. Compare Proposed Service to Existing Service. The Greyhound Bus Company presently operates scheduled passenger service between Gainesville, Georgia and Atlanta, Georgia with periodic stops in other Georgia cities including Flowery Branch, Buford, Lawrenceville, Suwanee, Duluth, Norcross, Doraville, and Chamblee. Tables 5 and 6 below illustrate the Greyhound Bus Company service between Atlanta and Gainesville.

Table 5. Greyhound Service from Atlanta to Gainesville

Leave Atlanta	Arrive Gainesville	Frequency
7:30 a.m.	9:15 a.m.	daily
1:15 p.m.	2:24 p.m.	daily
2:00 p.m.	3:42 p.m.	daily
5:00 p.m.	6:47 p.m.	daily except Sundays and holidays
5:30 p.m.	7:10 p.m.	daily except Satur- days, Sundays, and holidays
10:45 p.m.	11:45 p.m.	daily

Table 6. Greyhound Service from Gainesville to Atlanta

Leave Gainesville	Arrive Atlanta	Frequency
6:10 a.m.	7:45 a.m.	daily except Saturdays, Sundays, and holidays
6:41 a.m.	8:45 a.m.	daily except Sundays and holidays
9:25 a.m.	11:28 a.m.	daily
3:35 p.m.	5:25 p.m.	daily
8:02 p.m.	9:15 p.m.	daily

Source: Greyhound Timetable 112.

The average trip time from Doraville to Gainesville on Greyhound is 32 minutes whereas the trip time from Gainesville to Doraville is 85 minutes. Use 58 minutes travel time for Greyhound service when comparing it with the proposed bus service.

Tables 7, 8, and 9 indicate total travel time from the three origins in Hall County to the five destinations in Atlanta for both Greyhound and the proposed bus service.

Table 7. Total Bus Trip Time from Gainesville to Atlanta

Atlanta Destination	Greyhound	Bus Rapid
1. Georgia Tech Campus	97	79
2. Fulton Industrial Park	115	97
3. Executive Park	93	75
4. Equitable Building	96	78
5. Airport Terminal	108	90

Table 8. Total Bus Trip Time from Oakwood to Atlanta

Atlanta Destination	Greyhound	Bus Rapid
1. Georgia Tech Campus	85	67
2. Fulton Industrial Park	103	85
3. Executive Park	81	63
4. Equitable Building	84	66
5. Airport Terminal	96	78

Table 9. Total Bus Trip Time from Flowery Branch to Atlanta

Atlanta Destination	Greyhound	Bus Rapid
1. Georgia Tech Campus	77	59
2. Fulton Industrial Park	95	77
3. Executive Park	73	55
4. Equitable Building	76	58
5. Airport Terminal	88	70

Note: All times are in minutes (portal-to-portal).

Trip fare on the Greyhound Bus is \$2.42 whereas the proposed bus service has a fare of \$2.00 (cost per passenger trip). In comparing these costs, sample destinations have the same cost for each origin because both services terminate at Doraville and use MARTA for distribution throughout Atlanta. Table 10 lists total travel costs from Gainesville, Oakwood, and Flowery Branch to Atlanta for Greyhound and the proposed bus rapid service.

Table 10. Total Bus Costs from Hall County to Atlanta

Origin	Service Type	
	Greyhound	Bus Rapid
1. Gainesville	\$3.10	\$2.68
2. Oakwood	2.95	2.53
3. Flowery Branch	2.92	2.50

Note: All travel costs are one-way passenger trips. It is assumed that 1.6 passengers per car drive to the station.

The "equivalent travel cost" for every trip favors the proposed bus service by \$1.32. It is not necessary to examine the list of non-quantifiable factors. The proposed bus service is clearly "better" than the existing Greyhound service.

Step 10. Have All Services Been Examined? No. Go to next step.

Step 11. Select Next Service. Rail transportation is investigated.

CHAPTER V

TRAIN SERVICE

Commuter rail service is the second of three alternative modes of transporting people between Gainesville and Atlanta. Rail service is described in four sections: Service Description, Service Characteristics, Service Costs, and Service Mathematics. The Service Description details the proposed service including facilities, operating procedures, and operating hours. The Service Characteristics include train selection and train costs, acceleration and deceleration rates, average line-haul speed, station location, and the manner in which transfer to MARTA will be performed (Step 6). Service Costs describe the operating costs and their calculation method and the associated passenger costs (Step 7). Service Mathematics illustrate the equations used in the travel time computations (Step 8). Finally, comparisons between the proposed service and existing rail service are made (Step 9).

Step 6. Describe Proposed Service and Formulate Service Characteristics.

Service Description

The commuter rail service will operate between Gainesville, Georgia and Doraville, Georgia, a distance of 37 railroad miles. There will be two stops in Hall County and each stop will last 0.5 minutes. These two stops will be located strategically in order to be accessible to a large number of potential riders.

The rail service will start in Gainesville, Georgia and travel over the Southern Railroad tracks towards Doraville, Georgia. Commuters using this service will travel at high speeds and will ride in air-conditioned comfort. The train crew will be professional and employed by Southern Railroad. Initially, only two trips will be made--one trip in the morning rush hour from Gainesville to Doraville and a return trip during the evening rush hour. As ridership increases more passenger cars or more trains will be added and the level of service increased. The service will operate five days a week, 52 weeks per year for a total of 254 days each year (holidays excluded).

Service Characteristics

The Southern Railroad Company presently owns the rights to operate scheduled passenger service between Gainesville, Georgia and Atlanta, Georgia. The only track between these two cities is owned, operated, and maintained by Southern. Therefore, a cooperative effort between Southern Railroad and the commuters is a prerequisite to success. This obstacle may be overcome by negotiating a contract with Southern to operate a charter service over their tracks between the two cities. It will be assumed that Southern is receptive to this offer.

The agreement will call for Southern Railroad to supply the crew, equipment, station, and be responsible for all details concerning operating, owning, and maintaining the system except for fare collection. The train will consist of one 2070 HP locomotive and two 78-seat passenger cars. The crew will consist of train enginemen

and trainmen (a crew of two will be used for each train). The fares will be collected by an appointee of the club treasurer.

The cost assumptions are based on the cost of the equipment to Southern Railway plus a profit margin. The "ICC: Annual Report on Transport Statistics in the U.S. for the Year Ended December 31, 1970" was used to calculate the charter cost of the equipment in this service.*

The estimating procedure required the use of Southern Railroad's balance sheets as contained in the ICC statistics. Passenger train costs were separated from freight train costs and then the cost of operating and maintaining the commuter train was extracted. The charge for "chartering" the train was based upon the expenses incurred by Southern plus their profit margin. Further details are found under Service Costs.

The 1970 ICC cost data of Southern Railroad are used to compute 1975 commuter costs. Table 11 reveals interesting comparisons between Southern's cost of passenger service operation in 1970 and 1972.

According to the table, both passenger service and passenger cost were reduced nearly proportionately. In fact, operating expenses were reduced almost 50 percent greater than service. This fact represents a situation involving the economies of scale of the operation, in addition to the formation of Amtrak and subsequent take-over of the majority of United States passenger service. With this particular

*Although there is much controversy concerning rail costs, the ICC statistics are generally accepted to represent costs.

Table 11. Southern Passenger Service Comparisons for
1970 and 1972

Item	Percent Change from 1970 to 1972
Total Passenger Train-Miles	-45
Total Locomotive Unit-Miles	-53
Total Passenger Car-Miles	-45
Total Passenger Expenses	-62

Source: ICC Selected Income and Balance Sheets of Class I Railroads in U.S.

in mind, it is assumed that the operating costs in 1975 will be the same as those in 1970. This assumption is further supported in that the expense computations are factored slightly upward for error protection.

The average line-haul velocity of the train is 75 mph. A check of the horizontal alinements along the track reveals that at no place is a 5° curve exceeded. On one occasion there is a 4.2° curve and twice there are 4.1° curves, however, the remaining horizontal curves are significantly less. An examination of the vertical alinements discloses that at no place is a 2 percent grade exceeded for more than 2,000 feet.

The deceleration rate of the train will be a constant 3 fps/sec; this value is an average over the entire speed range from 75 mph.

MARTA will play a significant role in solving the distribution problem at the Atlanta end of the trip. Transfer from the train to

MARTA will be made at the Doraville station with little difficulty.* The train will pull up to the station and an across-platform transfer will take place. This method is very straightforward and simple to perform.

There are at present three terminals along the Southern Railroad tracks in Hall County. The Gainesville and Flowery Branch stations are passenger terminals and the Oakwood station is solely used as a freight terminal. The Oakwood station is only 5.8 miles from the Gainesville station. Because of this short distance it would not be operationally attractive to stop at Oakwood. The proximity of Oakwood to either Gainesville or Flowery Branch causes little inconvenience to travelers from those areas.**

The Flowery Branch station is 9.2 miles from Gainesville and a stop at Flowery Branch will be established. This location will be ideal for several reasons. The residents of Oakwood will be served by either terminal and the residents near Lake Lanier Islands will also be served. In addition, the vertical alinement is such that start-up movement in either direction is easily performed. Therefore, the initial commuter service will utilize two of Southern Railroad's terminals.

*The location of MARTA is adjacent to the Southern Railroad right-of-way.

**Service originating at Oakwood is a future possibility depending on demand. This service would require alterations at the Oakwood Freight Terminal to accommodate passenger service. An improvement in parking facilities would also be desirable.

Step 7. Compute Service Costs.

Service Costs

Operating Costs

The commuter service will charter a passenger train consisting of one locomotive unit and two passenger cars. The basic procedure in computing the passenger train operating cost involves determining the average length of a typical Southern Railroad passenger train and the cost of operating this average passenger train length over their own exclusive tracks. Next, the average-horsepower passenger train locomotive is calculated. It is now assumed that both locomotive units and passenger cars have identical operating expenses when fuel, maintenance, and labor costs are deleted. This operating cost represents a base cost for an entire average-length passenger train for Southern Railroad with identical units of rolling stock. To this amount, the fuel and maintenance costs for the locomotive unit and the labor costs for the passenger cars are added to the base cost of the rolling stock to obtain Southern Railroad's cost of operating a typical commuter train for this service.

The average Southern Railroad passenger train consists of three locomotive units and ten passenger cars. These figures were computed in the following manner:

$$\frac{\text{total locomotive unit-miles in passenger road service}}{\text{total passenger train-miles}} \approx 3 \text{ units}$$

and

$$\frac{\text{total passenger car-miles}}{\text{total passenger train-miles}} \approx 10 \text{ cars} .$$

The total passenger expenses from the ICC statistics include:

Maintenance of way and structures	\$ 1,831,788
Maintenance of equipment	5,376,940
Traffic	259,357
Transportation rail line	10,790,074
Miscellaneous operations	749,018
General	<u>2,067,954</u>
Grand Total Passenger Expenses	\$21,075,131

However, several corrections will be made to these expenses. Firstly, the transportation rail line expenses are high and will be adjusted to exclude the following costs: train engineman, train fuel, lubricants for train locomotives, trainmen, other supplies for train locomotives, signal and interlocker operation, communication system operation, employees' health and welfare benefits, and insurance.

The transportation rail line expenses associated with passenger service are determined by allocating the expenses, both passenger and freight, according to the ratio of train-miles. The computation is as follows:

$$\frac{\text{passenger train-miles}}{\text{total transportation service train-miles}} \times \text{total transportation rail line expenses}$$

or

$$\frac{1,406,134}{16,537,703} \times \$49,142,000 = \$4,200,000 .$$

The cost figure for total transportation rail line expenses includes only those items cited in the list above for passenger and freight

service. This calculated figure was rounded upward 20 percent to \$5 million to include error protection and profit margin.

The cost figure for general expenses will also be corrected. According to the ICC statistics, general expenses* attributed to passenger service amounted to \$2,067,954. A minimal amount of general expense will be incurred by Southern Railroad in the administering of the commuter service because these functions will either be handled by the commuter club or fail to be influenced by the commuter service. On the basis of train-miles, 8.5 percent of this cost is assignable to passenger service whereas 10 percent of general expenses is apportioned to passenger service. An overwhelming majority of Southern Railroad's business is with freight service, and for this reason, the staff required to administer passenger service should not be very large. However, to account for personnel and their services, Southern Railroad's profit margin, and error protection, it is assumed that 50 percent of the total is more realistic and accurate (\$1,033,977).

The grand total of expenses associated with operating passenger service is \$14,251,080 and the total passenger train-miles, 1,406,134. The passenger expense, therefore, will be \$10.12 per passenger train-mile (for a 3 locomotive unit and 10 passenger car train).

The 2000-horsepower locomotive unit was chosen for several reasons. For acceleration and velocity reasons on vertical alignments, a 2000-horsepower locomotive will be sufficient. In addition, the

*General Expenses include salaries and expenses of general officers, clerks, attendants, general office supplies and expenses, law expenses, insurance, employees' health and welfare benefits, pensions, and stationery and printing.

average horsepower per locomotive unit for Southern Railway is nearly this size which will facilitate fuel computations later in the analysis. The computation is performed in the following way:

$$\frac{\text{total horsepower : diesel locomotive units}}{\text{average number of units during the year}}$$

or

$$\frac{1,438,060}{693} \approx 2070 \text{ Hp per locomotive unit .}$$

The operating cost of the average passenger train (3 locomotive units plus 10 passenger cars) has now been found and the base cost for 13 units of rolling stock is sought. The base cost can be determined by subtracting fuel, maintenance, and labor from the average passenger train cost.

Labor costs for the locomotives are calculated to be:

$$\frac{\text{train engineman + trainmen}}{\text{total transportation service in train-miles}}$$

or

$$\frac{11,054,178 + 18,436,539}{16,537,703} = \$1.78 \text{ per passenger train-mile .}$$

Annual maintenance costs per passenger train-mile consist mainly of diesel locomotive repairs. The cost is computed:

$$\frac{\text{total passenger locomotive unit-miles}}{\text{total locomotive unit-miles}} \times \frac{\text{diesel repairs}}{1} \times \frac{\text{road service pass. loco. unit-miles}}{1}$$

or

$$\frac{4,477,905}{58,219,859} \times 12,284,108 \times \frac{1}{4,268,715} = \$0.22 \text{ per passenger loco-} \\ \text{motive unit-mile}$$

Since there are three locomotive units in a typical passenger train configuration, the cost will be \$0.66.

Fuel consumption per locomotive unit-mile is calculated and using this rate, fuel costs per locomotive unit-mile are determined. The diesel oil cost in 1970 was 11¢ per gallon for the entire southern district of the United States. To calculate the gallons per locomotive unit-mile, use the formula:

$$\frac{\text{total diesel fuel cost}}{\text{cost/gallon}} \times \frac{1}{\text{total locomotive unit-miles for passenger service}}$$

Fuel usage, on the average, is 2.28 gallons per locomotive unit-mile. Therefore, the fuel cost per locomotive unit-mile (with 3 locomotives) is:

$$2.28 \frac{\text{gallons}}{\text{locomotive unit-mile}} \times 3 \text{ locomotives} \times 11 \frac{\text{cents}}{\text{gallon}}$$

or 75 cents.*

*Fuel cost per locomotive unit-mile can be approximated in the following manner. Assume that locomotive unit has 2000 horsepower and is 38 percent efficient. Further assume that diesel fuel weighs 7 lbs per gallon and average train speed is 60 mph. Therefore, the fuel consumption rate is:

$$\frac{2000 \text{ Hp}}{38\%} \times \frac{2,544 \text{ Btu-lb}}{19,550 \text{ Btu Hp-hr}} \times \frac{\text{gallon}}{7 \text{ lbs}} \times \frac{\text{hour}}{60 \text{ miles}} = 1.61 \text{ gal unit-mile}$$

Using the consumption rate of 1.61 gallons per locomotive unit-mile, fuel cost per locomotive unit-mile is calculated to be 51 cents. The higher figure is used and rounded to 80 cents.

The base cost per passenger train-mile can now be determined by subtracting maintenance, labor, and fuel costs from the passenger train-mile cost for a three locomotive unit and ten passenger car train. The computation is performed below.

Operating Cost	\$10.12
- Maintenance Cost	0.66
- Labor Cost	1.78
- Fuel Cost	<u>0.80</u>
Base Cost	\$6.78

Note: All costs are per passenger train-mile.

Since the base cost consists of 13 identical units of rolling stock, dividing this total by 13 yields the base cost per unit of rolling stock-mile. The resulting base cost is 52 cents per unit of rolling stock-mile. The next step involves determining the commuter train operating cost for the proposed service.

The commuter train consists of one locomotive unit and two passenger cars. Three units of rolling stock will be used to compute the operating cost. Add to the operating cost of the rolling stock, labor, maintenance, and fuel, and the commuter train cost emerges. The calculation is illustrated here:

Base Cost per rolling stock unit-mile times 3	1.56
+ Maintenance Cost per locomotive unit-mile times 3	0.22
+ Labor Cost per locomotive unit-mile times 1	0.71*
+ <u>Fuel Cost per locomotive unit-mile times 1</u>	<u>0.25</u>
Commuter Train Cost per train-mile	2.74

Passenger Costs

The total operating costs will be offset entirely by fares collected from the commuters. Table 12 illustrates the expected cost per passenger per trip for three arbitrary load factors with two passenger card seating 78 passengers making two one-way trips per day for 254 days per year.

Table 12. Rail Service Passenger Costs

Load Factor	Passengers		One-Way Passenger Cost
	Per Day	Per Year	
100%	156	39,624	1.30
80	125	31,750	1.64
60	94	23,876	2.03

The costs listed under the right-hand column represent break-even costs which must be charged by the commuter service to cover all expenses. Profit to Southern Railroad has been included in the derivation. A fare of \$2.00 will be charged to each rider.

*The labor cost is 40 percent of \$1.78 because only two crewmen will be used in the service.

Service Mathematics

The equations of motion for railroad vehicles take into account vertical grades, horizontal curves, locomotive horsepower, and weight-inertia aspects of the cars. From its definition, locomotive tractive effort can be expressed in terms of the horsepower delivered to driving wheels and the locomotive speed.

$$TE = \frac{375 \text{ hp}'}{V'}$$

where

TE = tractive effort developed at the driving wheels (pounds)

hp' = horsepower delivered at driving wheels

V' = actual speed (mph)

To express tractive effort in terms of horsepower developed by the diesel engine prime mover, it is necessary to consider energy lost in the generator traction motors, reduction gears, and the control equipment. Locomotive builders and railroads have agreed on an average mechanical efficiency of 82.1 percent for analyzing and applying motive power and hence the modified tractive effort expression is:

$$TE = \frac{308 \text{ hp}}{V}$$

where

V = average speed from point to point (mph)

hp = rated horsepower of the diesel electric locomotive unit

Train resistance must also be considered. The relationships recommended by the American Railway Engineering Association in the

Manual for Railway Engineering [1] appears below:

$$R_{\ell} = 1.3 + \frac{29 a}{w_{\ell}} + 0.03 V + \frac{0.288 V^2}{w_{\ell}} + R_g + R_c$$

$$R_p = 1.3 + \frac{29 a}{w_p} + 0.045 V + \frac{0.0408 V^2}{w_p} + R_g + R_c$$

where

R_{ℓ} = locomotive unit resistance (pounds per ton)

R_p = passenger car resistance (pounds per ton)

a = number of axles per locomotive unit

w_{ℓ} = average locomotive unit weight (tons)

w_p = average passenger car weight including passengers (tons)

V = average speed from point to point (mph)

R_g = average grade resistance (pounds per ton)

$R_g = 20 \times \text{avg. \% grade}$

R_c = average curve resistance (pounds per ton)

The resistance to motion of a passenger train is the sum of the resistances of its component parts. Where n is the number of cars which a locomotive unit pulls, the train resistance (TR) is:

$$TR = w_{\ell} R_{\ell} + n w_p R_p$$

Tractive effort equated to train resistance is:

$$\frac{308 f \text{ hp}}{V} = w_{\ell} R_{\ell} + n w_p R_p$$

The difference between tractive effort and train resistance is the dynamic force which is

$$TE - TR = F = ma$$

To calculate train acceleration, solve for a:

$$a = \frac{TE - TR}{m}$$

To calculate the distance traveled by the train, use

$$s = \frac{(V_f^2 - V_o^2)}{(a_f + a_o)}$$

To calculate the time interval, use

$$t = \frac{V_f - V_o}{\left(\frac{a_f + a_o}{2}\right)}$$

The following values will be used in the computations:

$a = 4$	$f = 1$
$w_l = 125$	$hp = 2000$
$w_p = 85.08$	$n = 2$
$Rg = 5.0$	$m = \frac{\text{total wt}}{g} = 18,350$
$Rc = 0$	

The subsequent table (Table 13) of results is calculated with the above values.

Table 13. Trip Mathematics

V	TE	TR	TE - TR	a	S	t
0	45,000	2210.5	42,789.5	2.33	46.3	6.3
10	45,000	2370.6	42,629.4	2.10	60.8	3.3
15	41,067	2471.7	38,595.3	1.54	102.9	4.0
20	30,800	2597.8	28,202.2	1.19	178.1	5.4
25	24,640	2740.8	21,899.2	0.96	275.0	6.8
30	20,533	2891.9	17,641.2	0.79	397.5	8.4
35	17,600	3072.5	14,527.5	0.66	559.0	10.0
40	15,400	3265.6	12,134.4	0.56	749.0	12.0
45	13,689	3488.2	10,200.8	0.47	987.3	14.0
50	12,320	3735.8	8,584.2	0.39	1319.5	17.1
55	11,200	3966.3	7,233.7	0.33	1717.2	20.4
60	10,267	4256.0	6,011.0	0.27	2230.2	24.4
65	9,477	4541.1	4,935.9	0.21	3039.7	30.6
70	8,800	4855.7	3,944.3	0.17	4102.3	38.6
75	8,213	5182.8	3,030.2			
					15,764.8	201.3

Note: V (mph); TE, TR, TE - TR (lbs); a (fps²); S (feet); t (seconds).

Table 14 below lists travel times from Gainesville to intermediate stops and to the MARTA station in Doraville, Georgia.

Table 14. Rail Service Travel Times

Station	Distance (miles)	Travel Time (min)
Gainesville	0	0
Oakwood*	5.8	6
Flowery Branch	9.2	9
Doraville	37.0	32

*Although proposed service bypasses Oakwood station, it is included here for illustrative purposes. The travel time from Gainesville to Flowery Branch is non-stop.

Step 9. Compare Proposed Service to Existing Service. Southern Railroad operates passenger service between Atlanta, Georgia and Washington, D.C. each day per direction. The Southern Railway tracks pass through Gainesville and as a result, limited passenger service exists between Gainesville and Atlanta. Table 15 displays the scheduled passenger service between Gainesville and Atlanta.

Table 15. Southern Railway Passenger Service Between
Atlanta and Gainesville

Leave Atlanta	Arrive Gainesville	Frequency
7:00 a.m.	7:55 a.m.	daily
7:00 p.m.	7:55 p.m.	daily
Leave Gainesville	Arrive Atlanta	Frequency
7:55 a.m.	8:50 a.m.	daily
11:46 a.m.	12:55 p.m.	daily

Note: Atlanta terminal is located at Peachtree Street and I-85.
Source: Southern Railway System Passenger Train Schedule.

The average trip time from Atlanta to Gainesville is 55 minutes whereas the trip time from Gainesville to Atlanta is 62 minutes. For purposes of comparison use 58 minutes.

Tables 16, 17, and 18 indicate total travel time from the three origins in Hall County to the five destinations in Atlanta for both Southern Railroad and the proposed rail service.

Table 16. Total Train Times from Gainesville to Atlanta

Atlanta Destination	Southern	Proposed Service
1. Georgia Tech Campus	80	75
2. Fulton Industrial Park	98	93
3. Executive Park	76	71
4. Equitable Building	79	74
5. Airport Terminal	91	86

Table 17. Total Train Times from Oakwood to Atlanta

Atlanta Destination	Southern	Proposed Service
1. Georgia Tech Campus	73	70
2. Fulton Industrial Park	91	88
3. Executive Park	69	66
4. Equitable Building	72	69
5. Airport Terminal	84	81

Table 18. Total Train Times from Flowery Branch to Atlanta

Atlanta Destination	Southern	Proposed Service
1. Georgia Tech Campus	75	72
2. Fulton Industrial Park	93	90
3. Executive Park	71	68
4. Equitable Building	74	71
5. Airport Terminal	86	83

Note: All times are in minutes (portal-to-portal).

Trip fare on Southern Railroad is \$3.75 whereas the proposed rail service alternative has a fare of \$2.00 (cost per passenger trip). In comparing these costs, sample destinations have the same cost for each origin because both services terminate at Doraville and use MARTA for distribution throughout Atlanta. Table 19 lists the total travel costs from Gainesville, Oakwood, and Flowery Branch to Atlanta for Southern and the proposed rail service.

Table 19. Total Train Costs from Hall County to Atlanta

Origin	Service	
	Southern	Proposed Rail
1. Gainesville	\$3.75	\$2.49
2. Oakwood	3.94	2.68
3. Flowery Branch	4.03	2.77

Note: All travel costs are one-way passenger trips. It is assumed that 1.6 passengers per car drive to the station.

The "equivalent travel cost" for every trip favors the proposed rail service by at least \$1.41. It is not necessary to examine the list of non-quantifiable factors. The proposed rail service is clearly "better" than the existing rail service.

Step 10. Have All Services Been Examined? No. Go to next step.

Step 11. Select Next Service. Air transportation is investigated.

CHAPTER VI

AIR SERVICE

The commuter air service is the last of the three alternative services investigated for transporting people from Gainesville to Atlanta. Air service is presented in four parts: service description and service characteristics, service costs, trip times, and service comparisons. Service description presents the details of the proposed service including routes and operating hours. Service characteristics include assumptions unique to air operations such as airplane selections, cost estimating techniques, station locations, cruising speed, rate of climb, cruising altitudes, and the manner in which transfer to MARTA will be performed (Step 6). Service costs are computed (Step 7) and trip times are determined (Step 8). Finally, comparisons between air services are performed (Step 9).

Step 6. Describe Proposed Service and Formulate Service Characteristics.

Service Description

The commuter air service will operate between Gainesville and Atlanta. Service from Gainesville will originate at the Gainesville Municipal Airport. There are two alternate destinations in Atlanta: Fulton County Airport, located near the MARTA West Line, and Peachtree-DeKalb Airport, located near the MARTA Northeast Line. The airline distance between Gainesville and the Atlanta airports is 66 miles

and 39 miles respectively.

Atlanta's Hartsfield Airport, the second busiest commercial airport in the world, is a desirable choice for the destination in Atlanta due to its proximity to downtown Atlanta and its location at a MARTA transit station. However, Hartsfield is overcrowded with scheduled passenger service and time delays are frequent. In addition, high landing fees are charged at Hartsfield whereas Fulton County Airport and Peachtree-DeKalb Airport do not assess landing fees. Therefore, Hartsfield was excluded from the list of feasible terminal points in Atlanta.

The air service will start in Gainesville, Georgia and travel under IFR (Instrument Flight Rules) through the radar-controlled airways. Commuters using this service will travel at high-speeds and will ride in air-conditioned comfort. The pilot and flight engineer will be professionally qualified. Initially, two daily trips will be made using a single aircraft--one trip during the morning rush hour and one trip during the evening rush hour. As ridership increases more trips will be added. The service will be operated five days a week, 52 weeks per year for a total of 254 days each year (holidays excluded).

Service Assumptions

The air service can opt to fly under IFR (Instrument Flight Rules) or VFR (Visual Flight Rules) control. VFR travel time is faster during good weather but this control is not possible five to ten days of the year. For conservatism, all computations will consider the air service to be operated under IFR. IFR travel times

and costs are not likely to be exceeded during normal operations. Operationally when the opportunity presents itself, VFR will be followed; weather data suggest that IFR will be followed less than a dozen times each year. In basing the schedule on IFR, the service will rarely be tardy.

The airmiles from Gainesville, Georgia to the two airports in Atlanta will be increased by 15 percent to account for in-flight maneuvering--to 76 miles from Gainesville Municipal Airport to Fulton County Airport and to 45 miles to Peachtree-DeKalb Airport.

Two types of conventional take-off and landing (CTOL) aircraft will be considered for the air service--a large 60-passenger Fokker F27 MK600 and a small 19-passenger Swearingen Metro II. The major differences between the two planes are their passenger payloads and runway requirements. The Metro II can climb at a rate of 2000 fpm and the F27 MK600 can climb at 1700 fpm. For both aircraft, a 500 fpm climb will be observed for the final 1000 feet below cruising altitude.

A take-off distance of 2620 feet is required for the Metro II with a maximum take-off weight of 12,500 pounds. The F27 needs a runway length of 3240 feet with a maximum take-off weight of 40,000 pounds. Both fall well within the lengths of the runways at both airports.

An assumed headwind of 25 mph will be used, thus reducing average cruising speed of both aircraft from 200 mph to 175 mph. Similarly, the average take-off speed of 165 mph will be discounted to 145 mph using an average headwind of 20 mph. The cruising altitude will vary depending upon the flight direction and the type of control (IFR or VFR). Under IFR, an Atlanta to Gainesville trip will occur

at altitudes of 3000, 5000, 7000, 9000 feet above sea level; a return trip will use altitudes of 2000, 4000, 6000 feet above sea level. Under VFR control, the cruising altitudes will be increased by 500 feet.

Three options are available as a basis for determining travel costs: rent, charter, and own and operate the aircraft. Initially with the service limited to morning and afternoon peaks, the fixed cost of the aircraft will result in a high cost of ownership. It could be assumed that during the off-peak hours, the airplane is rented or chartered. However, the administrative burden of charter operations would not be possible in the commuter club environment. The problem of securing liability insurance would also be considerable. Therefore, aircraft charter is the assumed mode of operation.

MARTA will play a substantial role in solving the distribution problem at the Atlanta end of the trip. However, transfer to the MARTA Rapid Transit System will be more complex than for either the bus or rail services. Both Atlanta area airport destinations are removed from the rapid transit system; however, proposed feeder bus services from nearby rapid transit stations closely approach each airport. It is assumed that MARTA will detour its route to pick-up commuters and deliver them to the nearby transit station.

Stations

Fulton County Airport is located approximately 7.5 miles due west from downtown Atlanta off of Interstate-20. At an altitude of 800 feet, Fulton County has three runways with lengths of 2800, 4160, and 5800 feet and an FAA control tower with ILS (Instrument

Landing System) and PAR (Precision Approach Radar). The Fulton County Airport is located about 23 miles from the Fairburn Road Transit Station and feeder bus Route 67 will pass within 0.6 miles of the airport.

Peachtree-DeKalb Airport is located nearly 9.8 miles northeast of downtown Atlanta, off of Interstate-85. At an altitude of 987 feet, Peachtree-DeKalb has four runways with lengths of 3400, 3750, 4000, and 5000 feet and an FAA control tower with ILS and PAR. The Peachtree-DeKalb Airport is located approximately 1.1 miles from the Chamblee Transit Station and feeder bus Route 23 will travel within 0.4 miles of the airport.

Step 7. Compute Service Costs.

Operating Costs

Charter costs were computed on a formula basis with profit included. Cost calculations for charter service were performed in the following manner: cost of chartering will consider all operating costs including fuel and crew costs, parts and maintenance, insurance, depreciation, and a profit margin for the charter firm.

The service costs include both direct and indirect operating costs. Direct operating costs contain crew costs (salaries, expenses, insurance, payroll taxes, etc.), maintenance labor (wages, insurance, payroll taxes, etc.), fuel, oil, engine reserves, airframe parts, maintenance burden, hull and liability insurance, and aircraft depreciation. Indirect operating costs comprise general and administrative expenses, interest, fees, passenger service, promotion and sales.

The following table displays the basic data essential to the

cost computations:

Table 20. Basic Data Used in Air Service Costs

Fuel Cost/Gallons (in tanks)	\$ 0.65
Oil Cost/Gallon	11.67
2-Man Crew Cost/Flight Hour	26.00
Maintenance Labor Cost/manhour	7.22
Maintenance Burden--on labor only	50%
Engine O.H. Reserves	\$5,000 @ 2100 hr
	\$25,000 @ 4200 hr
Insurance:	
(a) % of total airplane cost	1.5%
(b) Per seat per year	\$285.00
Depreciation	8 or 12 years* @ 15%
Cost of aircraft	\$820,000 or \$2,100,000*
Utilization Flight Hours/Year	2565
Indirect Costs as percent of Direct Costs	10%

*Smaller figure pertains to Metro II.

Direct operating costs are of three types--fixed cost per flight hour, costs which vary with utilization, and fuel costs which vary with stage length and flight time. Fixed direct operating costs per flight hour include crew, oil, maintenance, engine overhaul reserves, airframe parts, and maintenance burden. The following list of computations illustrate the procedure for determining the fixed direct operating costs:

(a) Crew cost: =

(b) Oil cost:

$$(\text{cost/gallon}) \times (2 \text{ Eng}) \times \left(\frac{2.06 \text{ gal}}{300 \text{ flt hr}} + \frac{0.002 \text{ gal}}{\text{flt hr}} \right) =$$

(c) Maintenance:

$$1.4 \text{ hrs/flt hr} \times \text{labor cost/hr} =$$

(d) Engine Overhaul Reserves:

$$(2 \text{ Eng}) \left(\frac{5000}{2100 \text{ flt hr}} + \frac{25,000}{4200 \text{ flt hr}} \right) =$$

(e) Airframe Parts:

$$1.03 \left(2.5 + \frac{0.0079 (\text{Cost of Airplane less Engines})}{1000} \right) =$$

(f) Maintenance Burden (if based on labor only):

$$\frac{\% \text{ of burden}}{100} \times \text{maintenance labor cost} =$$

Total Fixed Direct
Operating Cost per
flight hour

Direct operating costs vary with yearly utilization. These costs consider insurance and depreciation. The following two components illustrate the calculations involved:

(a) Insurance:

$$\begin{aligned} & \frac{\text{Rate in \% Total Cost}}{100} \times \frac{\text{Total Airplane Cost}}{\text{Yearly Utilization}} \\ & + \frac{\text{Rate per Seat (19 or 60)}}{\text{Yearly Utilization}} = \end{aligned}$$

(b) Depreciation*:

$$\frac{(\text{Total Airplane Cost}) \times (0.85)}{(8 \text{ or } 12 \text{ years}) \text{ Yearly Utilization}} =$$

Total Direct Operating
Costs with Utilization

*This equation furnished by Swearingen [100], is not a capital recovery calculation but is an accounting calculation.

Fuel costs vary with both stage length and flight time. In calculating fuel costs it is necessary to include the fuel consumed during an arbitrary allowance of seven additional minutes which is added to off-to-on time to account for taxi, take-off, and air maneuver. Assume seven minutes as follows:

1 minute for take-off run

4 minutes for taxi

2 minutes for maneuver.

To calculate the fuel cost per flight hour, use the Air Transport Association of America (ATA) recommended formula:

$$\frac{\text{Fuel Cost/Gallon}}{6.7 \text{ lbs/Gallon}} \times \frac{\text{Block Fuel in lbs}}{\text{Flight Time in Hrs}}$$

The total direct operating cost per flight hour is the sum of total fixed direct operating costs per flight hour, plus total direct operating costs as a function of utilization, and fuel cost per flight hour. To compute the total direct operating cost per statute mile, employ the following formula:

$$\frac{(\text{D.O.C./Flight Hour}) \times (\text{Flight Time, Hrs})}{(\text{Stage Length, Statute Miles})}$$

Considering indirect costs as 10% of the total direct operating costs, T.C.D. (Total Operating Costs) per statute mile are:

$$\text{Direct Operating Costs/Statute Mile } (1 + 0.2\%)*$$

*An additional 10% is considered to account for the private carrier's profit margin.

Passenger Costs

The total operating costs per statute mile are a function of plane selection and airport destination. Tables 21 and 22 indicate the anticipated cost per passenger per trip for the Metro II and F27 respectively for three arbitrary load factors. The planes will offer 19 and 60 seats per trip with no reverse-commuting.

Table 21. Passenger Costs for Metro II

Load Factor	Passengers per Day	Cost per Passenger Trip	
		Peachtree-DeKalb	Fulton County
100%	114	\$ 8.30	\$12.20
80	90	10.50	15.50
60	66	14.30	21.00

Table 22. Passenger Costs for F27 MK600

Load Factor	Passengers per Day	Cost per Passenger-Trip	
		Peachtree-DeKalb	Fulton County
100%	360	\$8.40	\$5.20
80	288	4.30	6.50
60	216	5.70	8.60

Step 8. Determine Trip Travel Times.

Trip Travel Times

Travel time computations require some additional assumptions. The total travel time from one airport to the other can be fragmented

into nine parts for analysis purposes. The nine subdivisions are:

1. Passenger loading time
2. Taxi time including delay
3. Take-off run time
4. Climb time
5. Cruising altitude time
6. Descent time from 2000 feet
7. Landing time
8. Taxi time
9. Passenger unloading time

Boarding times are assumed to last one minute each. Taxi times including delays will be two minutes each for both airports. The taxi time at Gainesville Municipal Airport will be virtually zero due to the proximity of the runway to the apron. Similarly, the two general aviation airports in Atlanta are very compact, but a small delay may occur. The take-off run and touch-down deceleration will be 0.5 minutes each.

The average climbing rate is assumed to be 1700 fpm for the F27 MK600 and 2000 fpm for the Metro II. As the aircraft lifts off the runway, these average climbing rates are assumed to be in effect.* In other words to climb 3400 feet, the F27 would need two minutes and the Metro II 1.7 minutes. The final 1000 feet below cruising altitude climbed in two minutes (500 fpm). Meanwhile the speed has remained constant during the entire climb at the previously cited figures.

*At the end of the take-off run when the aircraft lifts off the runway, the plane is assumed to be at its average take-off speed.

The plane will now cruise at its average cruising speed and slowly descend to 2000 feet above the airport elevation. The final 2000-foot descent will take four minutes at 500 fpm and then the touch-down occurs.

Table 23 below summarizes the airplane travel times from Gainesville to the two Atlanta area airports under IFR control.

Table 23. Air Service Travel Times

Airport	Distance	Total Travel Time
Gainesville to		
Peachtree-DeKalb	45	25.1
Fulton County	76	35.7
Gainesville from		
Peachtree-DeKalb	45	25.2
Fulton County	76	35.9

Note: Total travel time is from boarding and take-off to touchdown and deplaning. An additional five minutes was included in the travel time to account for take-off run and taxi. The travel times above apply to both aircraft types as trip time differences are negligible.

Step 9. Compare Proposed Service to Existing Service.

Comparison to Existing Service

At present there is no air commuter service to Gainesville from Atlanta. Air South, about five years ago, operated commuter service between these cities, but it was forced to cease operations due to low patronages.

It is not possible to compare proposed service to existing service, but it is possible to compare, contrast, and evaluate two

proposed air service equipment alternatives. This step is performed in order to select the "more promising" equipment alternative to be compared with the other alternative systems in the next chapter.

As indicated in the prior step, "Air Service Travel Times" are essentially the same for both equipment alternatives. The following tables indicate total travel times from the three sample origins in Hall County to the five Atlanta destinations for both the Metro II and F27 MK600.

Table 24. Total Air Service Time from Gainesville to Atlanta

Atlanta Destination	Metro II or F27 MK600
1. Georgia Tech Campus	63
2. Fulton Industrial Park	81
3. Executive Park	59
4. Equitable Building	62
5. Airport Terminal	74

Table 25. Total Air Service Time from Oakwood to Atlanta

Atlanta Destination	Metro II or F27 MK600
1. Georgia Tech Campus	74
2. Fulton Industrial Park	92
3. Executive Park	70
4. Equitable Building	73
5. Airport Terminal	85

Table 26. Total Air Service Time from Flowery Branch to Atlanta

Atlanta Destination	Metro II or F27 MK600
1. Georgia Tech Campus	75
2. Fulton Industrial Park	93
3. Executive Park	71
4. Equitable Building	74
5. Airport Terminal	86

Note: All times are in minutes (portal-to-portal). Air times are identical for both planes.

Total travel costs are different for the two airplanes, however, each origin in Hall County has the same trip cost for all sample destinations in Atlanta. This is true because both alternatives utilize MARTA for distribution throughout Atlanta. Table 27 displays total trip costs for both airservice equipment selections.

Table 27. Total Air Service Costs from Hall County to Atlanta

Origin	Metro II	F27 MK600
1. Gainesville	\$5.80	\$4.00
2. Oakwood	6.50	4.70
3. Flowery Branch	6.90	5.10

Note: All travel costs are one-way passenger trips. It is assumed that 1.6 passengers per car drive to the station.

The "equivalent travel cost" for every trip favors the F27 over the Metro II by \$1.80. It is not necessary to examine the list of non-quantifiable factors. The F27 airplane is selected for use in the proposed air service.

Step 10. Have All Services Been Examined? Yes. Go to Step 12.

Step 12. Perform Comparisons, Evaluate, and Select Service.

All alternatives have been investigated and now we perform pairwise comparisons, evaluate the results, and select a service.

CHAPTER VII

SERVICE COMPARISONS AND EVALUATIONS

The purpose of this chapter is to evaluate and compare three alternative proposed travel services between Atlanta and Gainesville. Two groups of factors are used to compare alternative services: quantifiable factors and non-quantifiable factors.* The predominant mode in the travel corridor is the automobile and each alternative service is compared in a pairwise fashion with the automobile. First, the air service is compared with the automobile and then the bus service is compared. Finally, rail service is compared with the base system. In each analysis, both quantifiables and non-quantifiables are used to form the final outcome. At the conclusion of the comparisons, a service is selected.

The final segment of the chapter is devoted to a discussion of the results.

The yardstick or base in the comparative analysis is the automobile. In the previous chapters, travel times and trip costs have been calculated for various sample origins and destinations. The auto trip time and cost is computed for these same 15 trips and their comparisons are made.

The route selected for the automobile is determined by finding

*If the analysis of quantifiable factors does not provide a well-defined solution, then non-quantifiable factors are investigated.

the shortest travel path and cheapest travel cost path between origin and destination. For the majority of trips, this path normally consists of using Ga. 365, I-85, and I-285.

Automobile Travel Costs

The cost of owning and operating a car consists of:

1. Original vehicle cost depreciated
2. Maintenance, accessories, parts, and tires
3. Gas and oil (taxes excluded)
4. Garage, parking, and tolls
5. Insurance
6. State and Federal taxes

Table 28 below lists a typical breakdown of costs for a standard size vehicle.

Table 28. Operating Cost of An Automobile

	Cents/Mile
Original vehicle cost depreciated*	4.2
Maintenance, accessories, parts, and tires	3.4
Gas and oil (taxes excluded)	3.2
Insurance	1.6
State and Federal taxes	<u>1.5</u>
Total	13.9

*The assumed vehicle life is 100,000 miles over a 10-year period; a salvage value of \$50 exists at that time.

Source: Cost of Operating An Automobile by L. L. Liston and R. W. Sherrer [57].

The category "Garage, parking, and tolls" is omitted, however, it is added into total cost computations for the fifteen sample trips wherever applicable. A cost of 15 cents per mile is used in the calculations. This cost includes a conservative inflation factor of 8 percent over the costs of Table 28 which were dated April, 1974.

In computing travel costs, parking fees are needed only for destinations 1 (Georgia Tech Campus) and 4 (Atlanta CBD). A cost of ten cents per day is incurred on the Tech campus and a garage cost of one dollar per day is charged for downtown parking. Tables 29, 30, and 31 list automobile travel costs from Gainesville, Oakwood, and Flowery Branch to the five destinations selected in the Atlanta area.

Table 29. Automobile Travel Costs from Gainesville to Atlanta

Atlanta Destination	Auto Mileage	Auto Cost
1. Georgia Tech Campus	56	\$7.00
2. Fulton Industrial Park	69	8.60
3. Executive Park	50	6.20
4. Equitable Building	61	8.00
5. Airport Terminal	72	9.00

Table 30. Automobile Travel Costs from Oakwood to Atlanta

Atlanta Destination	Auto Mileage	Auto Cost
1. Georgia Tech Campus	53	\$6.60
2. Fulton Industrial Park	66	8.20
3. Executive Park	47	5.80
4. Equitable Building	58	7.60
5. Airport Terminal	69	8.60

Table 31. Automobile Travel Costs from Flowery Branch to Atlanta

Atlanta Destination	Auto Mileage	Auto Cost
1. Georgia Tech Campus	47	\$5.90
2. Fulton Industrial Park	60	7.50
3. Executive Park	41	5.10
4. Equitable Building	52	6.90
5. Airport Terminal	63	7.90

Note: All travel costs are for one-way passenger trips. It is assumed that 1.2 passengers per car commute via automobile to Atlanta.

Automobile Travel Times

The proposed services must be compared to the automobile for the same trip destinations. However, several additional simplified assumptions are needed. All trips within Hall County on non-interstate roads average 30 mph speeds, the average line-haul speed on Georgia 365 in Hall County and I-85 in Gwinnett County is 55 mph maximum. Travel times on I-85 within DeKalb and Fulton counties are determined by travel time contours performed for the State Highway Department of Georgia in a recent study [76]. I-285 travel time is based upon an average speed of 45 mph.

Tables 32, 33, and 34 below indicate total travel times from the three sample origins in Hall County to the five Atlanta destinations for the automobile.

Table 32. Total Auto Trip Time from Gainesville to Atlanta

Atlanta Destination	Auto Mileage	Auto Time
1. Georgia Tech Campus	56	75
2. Fulton Industrial Park	69	84
3. Executive Park	50	64
4. Equitable Building	61	87
5. Airport Terminal	72	90

Table 33. Total Auto Trip Time from Oakwood to Atlanta

Atlanta Destination	Auto Mileage	Auto Time
1. Georgia Tech Campus	53	74
2. Fulton Industrial Park	66	81
3. Executive Park	47	63
4. Equitable Building	58	86
5. Airport Terminal	69	88

Table 34. Total Auto Trip Time from Flowery Branch to Atlanta

Atlanta Destination	Auto Mileage	Auto Time
1. Georgia Tech Campus	47	70
2. Fulton Industrial Park	60	75
3. Executive Park	41	58
4. Equitable Building	52	81
5. Airport Terminal	63	82

Note: All times are in minutes (portal-to-portal).

Comparisons

Air Service versus Automobile

The air service is compared with the automobile on the basis of travel time and travel cost for 15 sample trips between the cities

(Atlanta and Gainesville). Total trip time and cost have already been determined for both services. In comparing these two services, "equivalent travel cost" differences are calculated. The following table displays "equivalent travel cost" differences between the proposed air service and the automobile.

Table 35. "Equivalent Travel Cost" Differences Between Air Service and Automobiles from Hall County to Atlanta

Origin	"Equivalent Travel Cost" Difference (Auto-Air)
1. Gainesville	\$21.90
2. Oakwood	13.20
3. Flowery Branch	6.20

Note: Each figure is the sum of the differences between the Hall County origin and the five Atlanta destinations.

The "equivalent travel cost" difference for the average trip favors the proposed air service by \$2.75. It is not necessary to examine the list of non-quantifiable factors as the proposed air service is clearly "better" than automobile commuting.

The new base or yardstick for comparison is the air service since it has lower "equivalent travel costs."

Bus Service versus Air Service

The bus service is compared with the air service on the basis of travel time and travel cost for 15 sample trips between Hall County and Atlanta. Total travel time and travel cost have previously been determined. "Equivalent travel cost" differences are computed to compare alternative services. The following table displays "equivalent

travel cost" differences between the bus service and air service.

Table 36. "Equivalent Travel Cost" Differences between Bus Service and Air Service from Hall County to Atlanta

Origin	"Equivalent Travel Cost" Difference (Bus-Air)
1. Gainesville	\$ 2.50
2. Oakwood	12.75
3. Flowery Branch	17.00

Note: All cost figures include the sum of all five Atlanta destinations.

The "equivalent travel cost" difference for the average trip favors the proposed bus service by \$2.25. It is not necessary to examine the list of non-quantifiable factors as the proposed bus service is clearly "better" than the air service.

The new base or standard for comparison is the bus service since it has lower "equivalent travel costs."

Rail Service versus Bus Service

Rail service is compared with bus service on the basis of travel time and travel cost for 15 sample trips between Hall County and Atlanta. Total travel time and trip cost have previously been computed. "Equivalent travel cost" differences are calculated to compare the differences between the alternative services. The table below displays "equivalent travel cost" differences between the rail service and bus service.

Table 37. "Equivalent Travel Cost" Differences Between Rail Service and Bus Service from Hall County to Atlanta

Origin	"Equivalent Travel Cost" Difference (Bus-Rail)
1. Gainesville	\$-1.20
2. Oakwood	3.50
3. Flowery Branch	4.75

Note: Each cost figure includes the sum for all Atlanta destinations.

The "equivalent travel cost" difference for the average trip favors the proposed bus service by \$0.50. This margin is very slim and it is necessary to examine non-quantifiable factors before a final decision should be made.

Non-quantifiable factors include convenience (transfers), comfort, frequency of service, travel time variability, service flexibility, implementation and reliability, safety, and available free time. Each one of these factors is briefly discussed comparing rail service to bus service.

1. Convenience. Excessive transfers can deter the use of public transportation. The route selected for both the rail service and bus service result in the same number of transfers.

2. Comfort. The train has restroom facilities with the additional capability of supplying bar service, limited food service, television viewing, radio broadcasts, and various seating arrangements for card playing, discussions, and so on. The bus has movable seats but no bathroom facilities. Higher passenger costs would be required to obtain bathroom facilities.

3. Frequency of Service. The bus service has two destination times per peak period whereas only one destination time is available on rail service. This additional departure clearly has its advantages.

4. Travel Time Variability. Rail travel experiences very minute travel time changes because trains operate over their own grade-separated right-of-way. Bus travel is made on surface roads, and as the bus approaches Metro Atlanta, congestion and traffic snarls can cause excessive delays. To partially overcome this potential problem, the bus service exits from the freeway as it nears Atlanta and transfers its patrons to the MARTA Rail Station at Doraville.

5. Service Flexibility. Flexibility in route, origin, and destination can influence travel time and patronage. Bus service can provide nearly portal-to-portal service given high demand for common origins and destinations, but the rail route is fixed and hence the number of origins and destinations is limited.

6. Service Implementation. Implementation is much easier for the bus than for rail. Railroads no longer desire to operate passenger service over their tracks as freight movement is without argument more profitable. Reaching an agreement with Southern Railway may not be possible--financially or otherwise--and this point should not be taken too lightly.

7. Service Reliability. Reliability is an important factor in inclement weather--heavy rains, fog, snow. Using a fixed-guideway system, rail service has only a small chance of delay or accident whereas bus operation can be adversely affected with any conditions other than ideal.

8. Safety. Rail service is by far safer than bus service.

The difference in safety between services is significant.

9. Available Free-Time. Riding to work as a passenger on the rail service or bus service affords its patrons the opportunity to read, contemplate, relax, converse, or sleep.

The rail service and bus service have been pairwise compared using non-quantifiable factors. A summary of these results are displayed in the table below.

Table 38. Non-Quantifiable Comparison for Bus and Rail

Non-Quantifiable Factor	Bus Service	Rail Service
1. Convenience	-	-
2. Comfort		F
3. Frequency of Service	F	
4. Travel Time Variability		F
5. Service Flexibility	F	
6. Service Implementation	F	
7. Service Reliability		F
8. Safety		F
9. Available Free-Time	-	-

Note: For each factor, an "F" is placed in the column for which the service is favored. A blank row indicates that neither service is "favored" with respect to that factor.

The non-quantifiable factors total four for rail and three for bus with two factors split evenly. Weighing the factors evenly, rail service is selected over bus service. It was assumed that preferential treatment was given to buses and a line-haul speed of 70 mph was used in the analysis. Relaxing this assumption and using 55 mph as the maximum line-haul speed, bus travel time increases six minutes. This

change alone reduces "equivalent travel cost" differences to 17 cents in favor of the bus. This difference is surely not overwhelming. Considering non-quantifiables, the rail service is a slim choice over bus service.

Rail service is recommended for the Gainesville-Atlanta transport system for the following reason: total travel time, total trip cost, travel time variability, service reliability and safety, and comfort favor rail service.

Van Pooling

Van pooling is a special type of transportation service and its merits deserve some attention here. The primary reason van pooling was eliminated from consideration was due to the availability of an adequate distribution system (MARTA) in the metropolitan area. The illustration involving Atlanta and Gainesville is not universally applicable to all urban areas because not all areas are served by public transit. For urban areas where distribution is non-existent, van pooling and bus service may be the solution. The cost components associated with van pooling are identical to those of the automobile. However, the cost per mile is somewhat higher.

Figure 5 is a graph comparing auto travel costs versus van pool travel costs for a trip length of 40 miles. The automobile is assumed to carry five passengers and cost 15 cents per mile to operate. The van is assumed to carry nine passengers and cost 30 cents per mile to operate [36]. The driver of the van is a paying customer.

The steps in the curves reflect incremental vehicle units. In other words, nine riders require one van or two automobiles. The

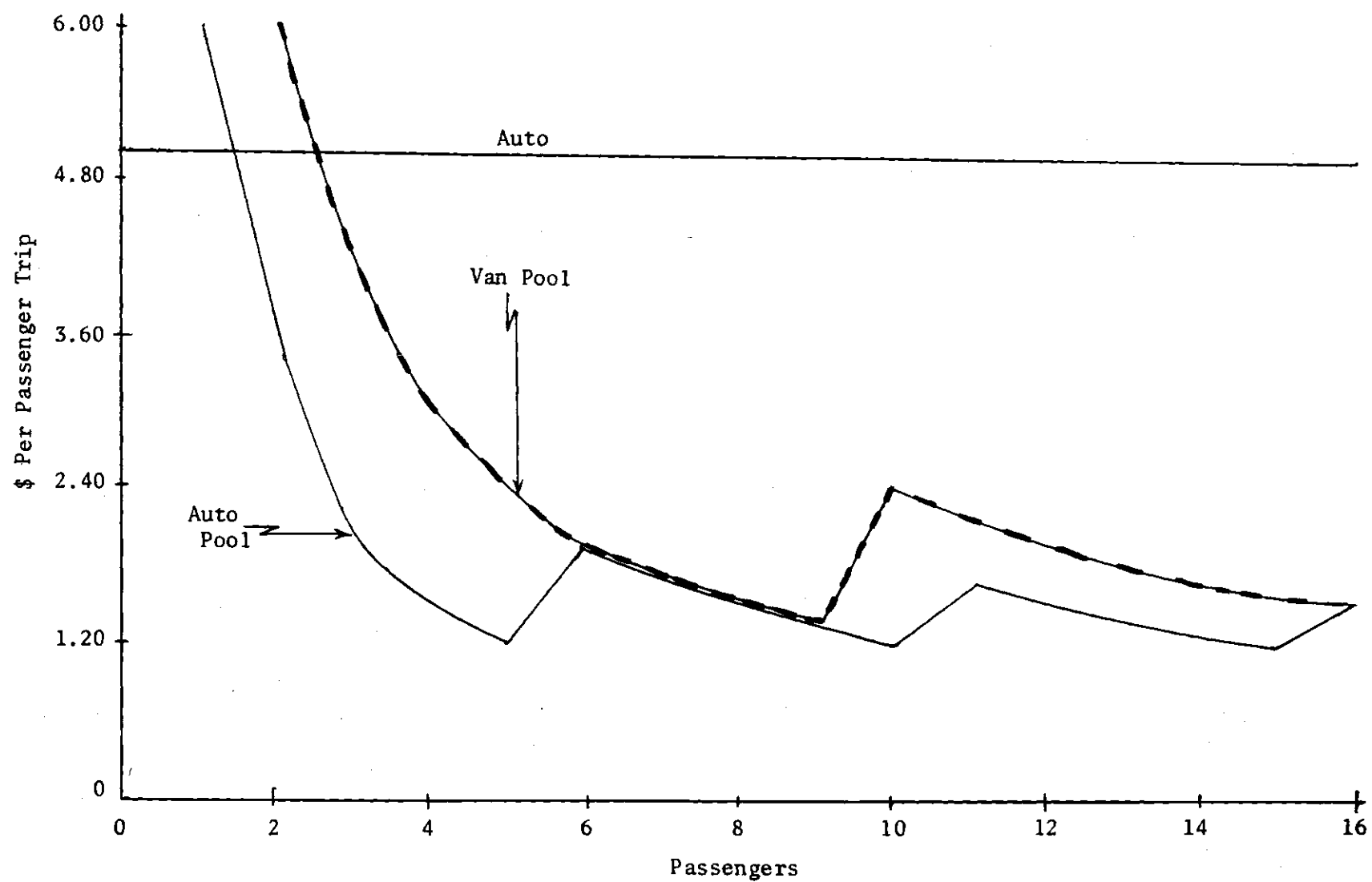


Figure 5. Graph of Travel Costs versus Patronage for Auto, Auto Pool, and Van Pool

curves may be misleading as it seems that automobile commuting is cheaper than van pooling. This is true in only one case. That is, if automobile commuters organize and form a car pool, then the graph would accurately depict those results. In practice, however, twelve riders would be using ten cars for commuter trips (1.2 passengers per car). The cost per passenger for a 40-mile trip and 1.2 passengers per auto is \$5.00. This cost is unaffected by patronage levels. Van pooling and auto pooling is much less than this trip cost.

Discussion of Results

If cheap, reliable, and convenient transportation (distribution) is provided in the urban area, then car pooling and van pooling can be eliminated and higher capacity-vehicles examined. The cost of using an air service alternative as opposed to bus or rail service is extremely high and air service of a distance of 50 miles is just not cost competitive. Bus and rail service are very close to one another in all categories and it is difficult to select one over the other for a generalization. There is no single choice service for all areas.

In comparing travel costs for bus service and rail service, total travel costs (portal-to-portal) were determined. The origins in Gainesville and the destinations in Atlanta were identical. The major differences were reflected in the location of the terminals or stations. As a result, travel time and trip cost from home to the terminal favored either the rail or the bus. This notion of location is inherent in any station location problem. However, we should be comparing bus with rail more or less on a line-haul basis. The

location of the station or stations can be an entire study in itself. Therefore, it is probably more realistic to examine line-haul travel costs for bus service and rail service. The terminating point is Doraville and the origin is Gainesville.

Figure 6 is a graph of line-haul travel cost versus patronage. For low levels of ridership bus service is cheaper, and as patronage grows, rail and bus service are cost competitive. The cost of automobile commuting is much more expensive for all levels of ridership. The steps in the curves, represent additional bus units or passenger cars. The final selection of a service will vary depending on the region studied. For example, bus service would be recommended where limited destinations in the urban area existed and public transit was inadequate.

The assumption regarding a commuter club is a valid one. Without it, passenger costs would surely be higher. Ownership of the service by a private organization would more than likely raise bus costs the least amount, with rail and air substantially more. The reason being that capital investment for rail and air service can be quite a bit costlier. The risk associated with a higher investment, such as for rail and air, is not at the same level as for bus service.

Travel costs have been computed using an interest rate of 10 percent, and although this rate is conservative, raising and lowering the rate has little effect upon bus or rail operations. Air service costs would decrease slightly if a lower rate were used. However, air service costs are very high and a small reduction would not have any significant impact on the existing ranking of alternatives.

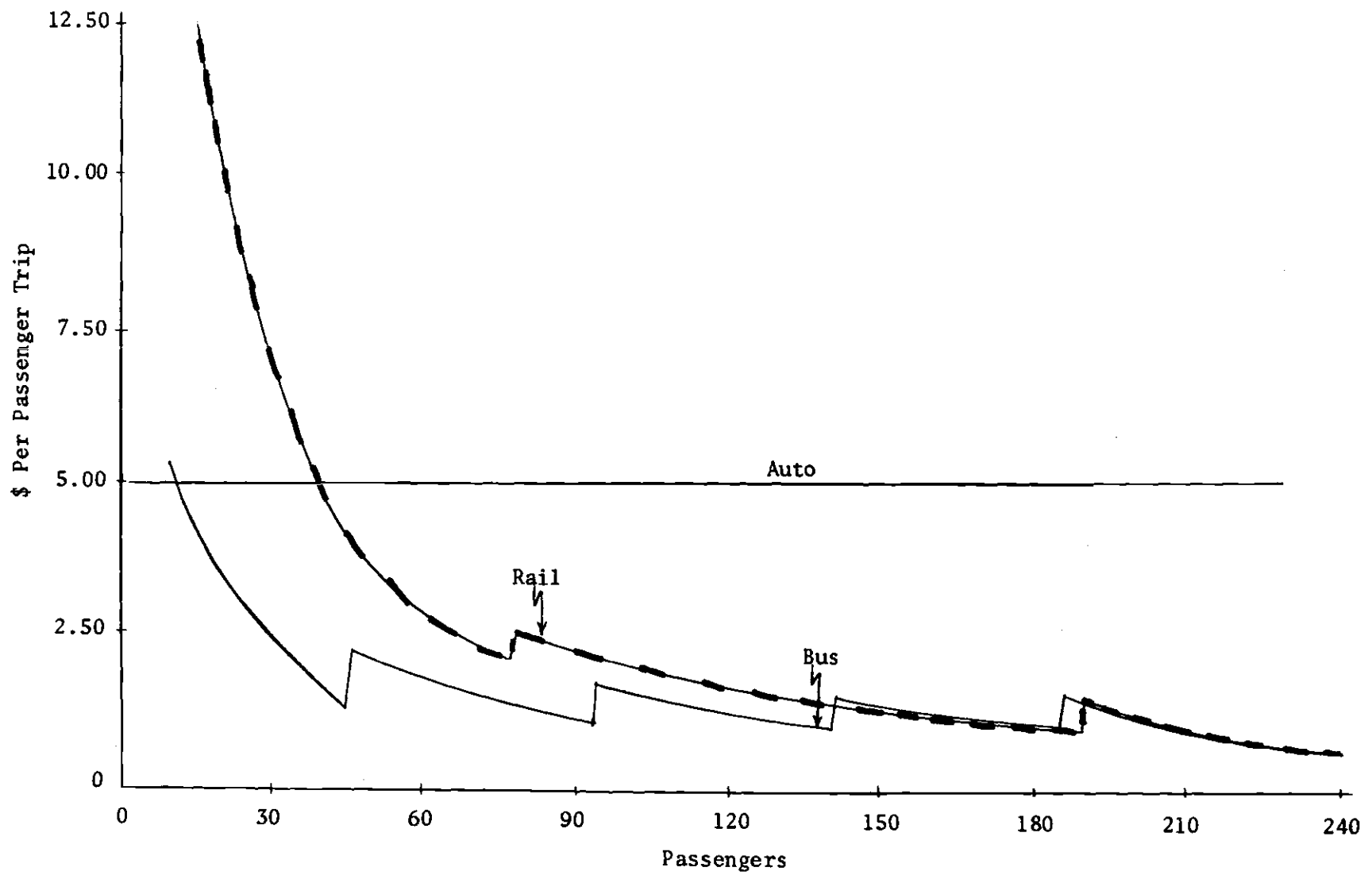


Figure 6. Graph of Line-Haul Travel Costs versus Patronage for Auto, Bus, and Rail

Travel cost computations have been performed using the MARTA system for distribution throughout Atlanta. For any urban area, public transit is going to be a subsidized operation. User taxes are levied on motorists that use highways and arterials for commutation and pleasure trips. Highway-user taxes are the major source of revenues for highway building and maintenance. Although only 9.5 percent of vehicle owning and operating costs pay for roads, the user of the system does pay a cost. In the case of transit, the Federal Government pays 80 percent of the capital cost, and in some instances, operating subsidies. The system in Atlanta is not untypical, a portion of the operating and capital costs is paid by citizens through sales taxes.

In a recently completed study [55], it was noted that residents of the MARTA area would be somewhat better off to encourage outsiders to use the system. The job of policing outsider use is, in itself, a fairly costly exercise if it is to be effective. Satellite area commuters working in the urban area will spend money for lunches, clothes, gifts, and so on and therefore contribute through sales taxes.

The transit system is designed to handle peak-hour loads and this period of time is when the "outsiders" will be using the system. The number of commuters arriving at any of the outlying stations is small compared to the nearby residents (of the urban area). The peak loading-point is not drastically altered--except for more standees--and no public transit system will ever turn their backs on potential customers. Although satellite commuters may not contribute their fair share, they do pay fares and contribute through sales taxes.

The comparative basis that was developed is dependent on the

on the selection of sample origins and destinations in order to evaluate the different services. These sample trips were designed to represent potential high-volume trips, and although only five were selected in the urban area, this number is sufficient. The sample destinations included the CBD, the airport, an industrial park, and fringe areas of the city. This type of destination selection would be valid for almost all cities.

CHAPTER VIII

CONCLUSIONS

Two types of conclusions can be drawn--those that relate to the analytical method and those that relate to the specific illustrative example. Concerning the analytical model,

- A method has been developed and illustrated that can be used to formulate and compare alternative transit services.
- This method can accommodate wide differences among alternatives specifically air, bus, and rail.
- The method guides formation of consistent assumptions.

The example has helped to develop insights into the satellite commuting problem. Although the illustration applies solely to Gainesville, Georgia, the similarity between Gainesville and other satellite areas suggests some general applications. These are included in the following listing.

1. Instituting a commuter service can be accomplished without having high-volume demand. Small units of demand can be accommodated with a successful commuter service. In addition, traditional transportation analysis techniques are neither directly applicable nor useful in estimating "latent" demand for satellite commuter transportation.

2. Commuter bus operations are easier to implement than rail or air service. With a fare of two dollars, 29 commuters are required to commence break-even bus operation. This small number of commuters

(demand) surely has its advantages.

3. The existence of an adequate (rapid) distribution system in an urban area is essential to the successful improvement of public transportation to a satellite area. If the assumption regarding the existence of MARTA's Rapid Transit System is relaxed, then the transit travel times within the metro area will increase substantially and eliminate the desirability of the proposed modes.

4. Construction of a rapid transit system extends the distance of maximum commute time. This distance is further lengthened with the addition of the proposed bus or rail commuter service.

5. Creation of a "Commuter Club" (charter service) most definitely improves the level of service of a system by eliminating costly organizational and administrative aspects ordinarily assumed by the private carrier. Portal-to-portal travel time is reduced. Travel costs for the bus and rail proposed systems are somewhat less than for Greyhound and Southern Railway systems, respectively.

6. Considering total travel time and line-haul length of approximately 40 miles, rail travel is second to air with auto and bus modes slower. As line-haul length decreases, rail travel becomes the quickest mode followed by bus, automobile, and air (in that order). Increasing the length favors air travel time, but the rail time is closely competitive. The automobile and bus modes are not nearly as fast.

7. Bus and rail travel costs compare favorably with automobile costs and rail travel time closely parallels auto trip time, however, bus times are slower.

8. In the rail versus bus comparisons, a two-car train is cost-competitive with the most efficient bus service using existing work rules. Assuming a crew of two, furthers this advantage. A one-car train is not cost-competitive with bus service given current labor rules, however, a one-car train has a slight cost advantage when considering more efficient work rules. With more than two passenger cars, a bus requires fewer people to fill, but if railroad commuter service can offer higher line-haul speeds than highways, passengers may very well prefer these higher speeds to the more frequent service possible with bus service.

9. For 40-mile line-haul service, both bus and rail travel costs are on par with one another. However, as the number of passengers increases on the rail mode, per passenger costs decrease at a greater rate than bus passenger costs. In other words, passenger costs are higher with the addition of two buses as opposed to the addition of one passenger car.

10. CTOL (Conventional Take-Off and Landing) air service of this commuting distance must be considered to be a premium service. Travel time is very competitive with both rail and bus, but travel cost is high. To more fully utilize the capabilities of the CTOL-type aircraft, a larger commuting radius is required. For service approaching the distance of 100 miles, air travel is more reasonably considered than at 40 miles.

11. The use of larger CTOL aircraft (in terms of payload) is more economical for commuter transport than small aircraft.

12. As true with most bus companies, operating expenses

represent a large portion of the total cost. For the proposed bus service, operating costs comprise 87 percent of the total cost.

13. Rail commuter service would be more cost-competitive with other modes if passenger trains were equipped with appropriate high-density, short-haul equipment and if out-moded work rules were abolished.

Opportunities for Future Investigations

Although all modes of transportation were investigated, not all forms of each mode were examined. Research has uncovered futuristic possibilities that may merit examination. Specific opportunities may be:

1. With respect to bus service, van pooling is desirable if a distribution problem exists at the urban area destination. Travel time is similar to the auto, but travel cost per passenger lies between the bus fare and auto operation costs.

2. Concerning rail operation, RDC's (Rail Diesel Cars) provide travel time and travel cost savings and permit a greater frequency of service to riders. Purchase of new RDC's must be made in bulk volumes and used equipment is scarce. Other self-propelled vehicles are available and some locales will benefit from its use.

3. Air service proved unsuccessful considering CTOL equipment and VTOL (Vertical Take-Off and Landing and V/STOL (Vertical-Short Take-Off and Landing) equipment also appears to be undesirable. However, STOL-aircraft (Short Take-Off and Landing) offers shorter runway length requirements and lower travel times. The design of STOL-crafts

is aimed at improving CTOL equipment to operate commuter service of this type.

APPENDIX

STATION DESIGN AND COST

Design

Each station will provide shelter against inclement weather, free park 'n ride spaces, parking area for the bus, and area for kiss 'n ride maneuvers. The parking lot will require the largest amount of land and the parking configuration will be the herringbone pattern as 45° parking is the most economical design. To provide enough spaces, design each station for one-third of two full busloads of passengers. This assumes that patrons will divide themselves uniformly amongst the three stations and that there will be no pedestrians, taxi cabs, and kiss 'n ride patrons. Each carload is assumed to contain 1.5 passengers. With a 100 percent load factor on both buses, a total of 94 passengers are possible each day. Therefore, 21 parking spaces will be required at each station. To park 24 cars in herringbone fashion, 8260 square feet is needed. In using 24 spaces, the three additional spaces will be set aside to accommodate bicycles and motorcycles.

The building or shelter will necessitate additional land. Fire Department regulations require 7 ft² per person in rooms where only drinks are served, 3 ft² per person for standing room only, and 15 ft² per person in rooms where food and tables are located. The shelter will contain benches for seating patrons and food concession machines. An adequate design figure of 10 ft² per person will be used. Although 21 parking spaces will be provided for both busloads, a 47-person

design station will be considered. When the commuter bus service attracts high volumes of riders, entire buses non-stop will be instituted from one station. Extending the parking lot capacity will not be nearly as difficult as expanding the shelter. Ten square feet are added to account for the concession area. The total shelter area will be 480 square feet.

The third and last category concerning land needs is the "catch-all" group entitled "miscellaneous." The area to be set aside here will be 5000 square feet which includes the parking area for the bus, five kiss 'n ride spaces, and pedestrian walks. Actually this figure is inflated over 100 percent to account for any forgotten details.

The total land area needed per station will be 14,500 square feet or one-third acre. The bus will park parallel to the roadway three to four feet off the shoulder directly in front of the shelter. Parking will be permitted behind the shelter for the park 'n ride mode and kiss 'n ride spaces will be supplied on the remaining three sides of the bus shelter. In using this type of design, a minimal amount of frontage on the main road is needed and hence the land cost will be held down.

Shelter Contents

The shelter will contain five five-foot double doors, five sets of six-foot long bench seats, a 4000-watt dual-capacity heater, a pay telephone, change machines, hot and cold food concession machines, newspaper stands, and trash facilities. Fire authorities recommend one door per 20 persons and this guideline will be followed.

By having two doors open to the bus, loading and unloading will be handled by both bus doors and hence twice as fast.

Seating requirements demand two crucial assumptions. Assume 100 percent load factor for the departing bus--this assumption is in line with the previous one regarding the 47-passenger design station. Assume only 60 percent of the patrons will want seats at any one time--(this assumption realizes that passengers will be reading newspapers, enjoying a cup of coffee, talking, and still arriving at the terminal. Hence, approximately 28 seats will be needed.

Heat will be necessary in the winter and this heat will be supplied by a Sears 2500, 4000-watt, dual-capacity heater. Assume:

ceiling insulation equal to 6 inches

wall insulation equal to 4 inches

floor or edge insulation in slab floors equal to 2 inches

storm sashes will be used.

The lowest average temperature is well above 20 degrees, although we shall use a watt-house factor equivalent to 55. Using a perimeter measurement of 92 feet, a 5060-watt heater will be needed to sustain a 75° inside temperature for the shelter. Considering that 75° is a bit warm and that the watt-house factor is slightly high, the dual-capacity heater will be adequate.

While passengers are waiting in the shelter, coffee, hot chocolate, soft drinks, and assorted snack foods may be purchased. It will be assumed that a vending machine company installs these machines. A pay telephone and change machines will also be supplied; newspaper stands will be installed to accommodate those riders who

prefer to read while riding the bus.

Trash will invariably be produced and receptacles will be purchased. Trash disposal will be dispensed in the customary manner.

Station Costs

The fixed costs for the commuter bus service appear below in Table 39. The initial cost of the heater is \$61.95; adding tax and

Table 39. Fixed Costs for Commuter Bus Service

Item	Initial Cost	Life	Annual Cost
1. Heater	\$70.00	15	\$ 30.90
2. Bench Seats			159.21
3. Land			720.00
4. Construction			2112.00
5. Paving			4830.00
6. Signing			83.22
7. Installation	1000.00	∞	360.00
8. Maintenance-misc.	--	--	150.00
9. Electricity	--	--	183.00
		Total	\$8628.33

Note: Initial cost is for one item and annual cost is for all three stations ($i = 12\%$).

an installation charge brings the total cost of \$70.00. The hardwood bench measure 72" x 13" x 18" and cost \$60.00 each. For the land and location nearby the interchanges, land cost per acre in Hall County will be \$6000. Assuming a building cost of \$10 per square foot, the construction cost will total \$4800. Paving and grading the terrain for an asphalt parking lot amounts to 70¢ per square foot or \$9100. Signing, markers, paint, and other traffic control devices will come to \$100. Installation of the outlets and the fixtures, plus wiring

the shelter, will cost an additional \$1000. The maintenance-miscellaneous category will allot \$50 per year for any unexpected problems or breakdowns. Lastly, electricity must be purchased from Georgia Power Company. Assuming an 8-hour day and 2.5 to 3¢ per kw-hr, \$61 per year will be the electric bill. The total sum of the fixed costs annually will be \$8628.33.

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